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FACULTY OF EDUCATION
The University of Alberta

Editorship of AJER

The Publications Committee is pleased to announce the appointment of Dr. Henry W. Hodysh, Associate Professor in the Department of Educational Foundations, as Editor of *AJER*. Dr. Hodysh completed his doctoral studies at the University of Alberta; his special interests are the history and philosophy of education and comparative education.

We look forward to his term in office as Editor and wish him well in his new responsibilities.

Before he joined the staff of the Faculty of Education in 1967, Dr. Hodysh served as a teacher with the Edmonton Public School Board. Since his appointment he has been involved in teaching at the graduate and undergraduate levels and conducting research into the history of education. From 1972 to 1975, Dr. Hodysh served as Assistant Dean in the Faculty of Education.

The results of his research have been published in various journals including *Educational Theory*, *History of Education Quarterly*, and *Paedagogica Historica*. Our readers will recall that Dr. Hodysh has also been a contributor to *AJER*.

The Publications Committee wishes to thank Dr. Andrew K. Clark for his service as Editor and for his contributions to the continued development of this journal.

E. Miklos, Chairmen
Faculty Publications Committee

Announcement

of the

CENTRE FOR RESEARCH IN TEACHING

The *Centre for Research in Teaching* has been established in the Faculty of Education of the University of Alberta. The Centre, which is the first of its kind in Canada, will have linkages with at least two similar units in the United States. Dr. D. A. MacKay has been appointed Coordinator of the Centre.

The Centre has as its main purposes, for the period July, 1977, to August, 1980, the following:

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2. To disseminate research findings that have particular significance for teachers, teacher educators, and research scholars.
3. To plan and implement a program of coordinated research in teaching and teacher education that will involve staff and graduate students of the Faculty of Education.
4. To ensure continuation and further expansion of this line of research beyond the three-year "seed period" by developing and presenting proposals for major funding to various external agencies.

Anyone wishing to contact the Centre may write to the following address:

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new from Manchester

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JAMES CUMMINS

and

J. P. DAS

The University of Alberta

Cognitive Processing and Reading Difficulties: A Framework for Research

The present paper outlines the potential of the simultaneous-successive model of cognitive processing as a framework for understanding and ultimately remediating reading difficulties. Recent studies suggest that among groups which might be expected to experience some difficulty in reading, successive processing is highly related to reading performance. However, at more advanced levels of reading, simultaneous processing is equally or more important for the development of fluent reading skills. The implications of these findings for research on reading disabilities are discussed. (Dr. Cummins is Research Associate at the Centre for the Study of Mental Retardation and Dr. Das is the Director of the Centre, Faculty of Education, The University of Alberta.)

Although the phenomenon of dyslexia or specific reading disability is still very inadequately understood, in recent years neuropsychological research has begun to delineate the brain-behaviour relationships which underlie certain types of reading difficulties. In this paper we shall synthesize recent research findings on the cognitive processing and linguistic abilities of reading disabled (RD) children within the framework of Luria's neuropsychological theory of simultaneous and successive processes. We shall first briefly outline Luria's theory and examine some recent studies which have related simultaneous and successive processing to the reading achievement of various groups of children. Then we shall attempt to show the potential of Luria's theory as a framework within which to investigate the cognitive processing of reading disabled children.

Luria (1966, 1970, 1973) has proposed a neuropsychological model which divides the human brain into three functional systems or blocks. The first block is responsible for maintaining wakefulness and arousal and consists of the upper brain stem, the reticular formation and the older parts of the limbic cortex and hippocampus. The second block includes the posterior cortex

consisting of parietal, occipital and fronto-temporal lobes and is responsible for the input, recoding and storage of information. Both simultaneous and successive processing occur in this second block. The third block of the brain consists of the prefrontal lobes and is responsible for the construction and execution of plans or programs. Through extensive connections with the other two blocks, it regulates and controls purposeful conscious action.

Simultaneous and successive processing were suggested by Luria on the basis of his observations of different types of cortical lesions and their behavioural correlates. Simultaneous processing involves the integration of the individual stimuli arriving at the brain into simultaneous and primarily spatial groups and is linked to the occipito-parietal area of the cortex. This type of processing is required in the formation of any holistic gestalt or in the discovery of the relationships among two or more objects. Although simultaneous synthesis has spatial overtones it is involved in several types of linguistic processing tasks. For example, understanding of logico-grammatical relations (e.g., "father's brother"), comparative constructions (e.g., "taller than"), and spatial prepositional constructions (e.g., above, below, etc.) all depend, according to Luria, on simultaneous processing.

Successive processing, in contrast, is linked to the fronto-temporal regions of the cortex and integrates individual stimuli into temporally organized successive series. As examples of successive processes Luria (1966) gives the automatization of skilled movements, rote memory, and narrative speech.

In a large number of studies (reviewed by Das, Kirby, & Jarman, 1975) it has been found that factor analyses of different types of reasoning and memory tasks can be parsimoniously interpreted in terms of simultaneous and successive processing. Simultaneous, successive and speed factors have emerged in studies involving many different clinical and cultural groups, e.g., retarded, learning disabled, native Indian, East Indian, as well as normal children. Thus, different cultural and clinical groups employ similar strategies of processing information. However, differences may exist between groups in preference for and proficiency in a particular strategy.

Linguistic Functioning and Simultaneous-Successive Processing

Luria's description of simultaneous and successive processes suggests that both modes of processing are involved in the individual's linguistic functioning. Because of the sequential nature of language and speech, successive processes are clearly important. However, as noted above, simultaneous processes are involved in understanding complex conceptual-linguistic relationships. We have recently investigated the relationship between simultaneous and successive processing and performance on a variety of linguistic tasks at the grade 3 level (Cummins & Das, 1977). Briefly, it was found that successive processing was significantly related to children's ability to analyze the linguistic form of propositions, specifically propositions which involved ambiguities in surface structure and deep structure. Simultaneous processing, on the other hand, was significantly related to performance on verbal reasoning tasks. In a previous study (Cummins, 1973), we have found that a syllogistic reasoning task involving comparative constructions and a task involving the discovery of semantic relationships between words both loaded on a simultaneous factor in high school students.

These findings are consistent with predictions derived from Luria's theory and suggest that simultaneous and successive processes are differentially important for different aspects of linguistic functioning.

However, the role of simultaneous and successive processing in linguistic functioning may vary between groups and at different developmental levels. It is possible for example, that successive processing of the linguistic input may be a prerequisite for deeper levels of semantic analysis involving simultaneous processes. Thus, in the reading process, successive processing may be important for the mastery of initial decoding skills but higher levels of fluent reading may depend more on simultaneous processing. In other words, among normal readers the conceptual-linguistic operations necessary for fluent reading may become independent of successive processing and consequently reading performance may relate more to simultaneous than to successive processing. However, among children who experience reading difficulties, initial deficits in successive processing may delay the differentiation of conceptual-linguistic operations from more elementary forms of sequential linguistic processing. If this is the case, we would expect that simultaneous and successive processing would relate differently to reading performance in low-achieving and normal readers. There are several studies which bear on this issue.

Reading Performance and Simultaneous-Successive Processing

Among RD and EMR children, reading difficulties have frequently been related to deficits in sequential processing. Doehring (1968) and Kinsbourne and Warrington (1966), for example, have reported that reading disability was significantly related to performance on tasks involving sequential processing. Blackman and his colleagues (Blackman, Bilsky, Burger & Mar, 1976; Blackman & Burger, 1972) have reported that sequential memory processes were highly related to the acquisition of word recognition skills among EMR children. Blackman et al., (1976) suggest that

those few mentally retarded subjects capable of deliberately generating strategies and applying them to the problem of recalling random digit strings may be able to generate and apply comparable strategies to the memory requirements — particularly those involved in decoding — of learning to read. (p. 132)

However, they suggest that although memory variables may be central to the acquisition of early reading skills in EMR populations, more complex cognitive variables may assume greater importance at more advanced levels of skills acquisition, such as comprehension in reading.

We have recently related simultaneous and successive processing to academic achievement in a group of 52 EMR children between the ages of 10 and 14. Simultaneous and successive factor scores derived from a factor analysis of four of the six marker tests in the Das battery (see Das, Kirby & Jarman, 1975) were correlated with the spelling, arithmetic, and oral reading subtests of the Wide Range Achievement Tests (WRAT) and with the Schonell silent reading subtest. These correlations are shown in Table 1.

It can be seen that successive processing correlates significantly with the WRAT oral reading and spelling subtests while simultaneous processing is significantly related to WRAT arithmetic. Silent reading which involves comprehension is related to neither processing strategy. These findings are

TABLE 1
CORRELATIONS BETWEEN ACHIEVEMENT AND SIMULTANEOUS-
SUCCESSIVE PROCESSING IN EMR CHILDREN

	Simultaneous	Successive
WRAT Spelling	-.21	.32*
WRAT Arithmetic	.28*	-.03
WRAT Oral Reading	-.17	.33*
Schonell Silent Reading	.09	.16

* $p < .05$

consistent with those of Blackman and his colleagues and suggest the importance of successive processing strategies for the development of decoding skills in EMR children.

Several other studies have related the Das battery of simultaneous and successive tasks to reading performance. Das, Manos and Kanungo (1975) compared the contributions of simultaneous and successive processing to reading achievement in high and low SES children. Briefly stated, the results indicated that the low SES group predominantly used successive processing as far as reading was concerned, whereas the high SES groups used a mixture of both processes. A recent study carried out by Hans Sprecht (unpublished) found that in a group of 65 low achieving high school students, reading achievement was significantly related to successive but not simultaneous tasks.

These findings suggest that low levels of successive processing ability may be a limiting factor in the reading achievement of RD, EMR, low SES and low achieving children. Krywaniuk (1974) and Kaufman (in preparation) have shown that teaching successive processing strategies to groups of poor readers led to significant improvements in decoding skills. It should not be inferred from these studies, however, that simultaneous processing is unrelated to reading performance. Satz (1976) has pointed out that "in early reading considerable weight is given to perceptual operations from which meaning is deduced from surface structure. By contrast, in later stages fluent reading is aided more by linguistic operations that sample the visual information to conform to prior expectations concerning meaning" (p. 279). Since, according to Luria, simultaneous processing is necessary for the discovery of conceptual relationships between objects and events, one would expect it to be involved at more advanced stages of reading. In studies involving children who are not experiencing reading difficulties we have indeed found this to be the case.

Kirby and Das (1977) divided a sample of 99 grade 4 children into four quadrants on the basis of median splits of simultaneous and successive factor scores and compared the performance of the four groups on the vocabulary and comprehension parts of the Gates McGinitie Reading Test. The results clearly showed that children high in both simultaneous and successive modes of processing had the highest level of reading achievement and children low in both modes had the lowest. The reading achievement of children high in one mode and low in the other was intermediate between the two extreme

groups and did not differ from each other. Kirby and Das conclude that high levels of simultaneous and successive processing are both necessary, though neither by itself is sufficient for high reading achievement.

We have recently followed up these findings with a study involving different criterion measures of reading achievement. Sixty grade 3 students were involved and the analytic procedure employed by Kirby and Das was again followed. Subjects were divided into four groups on the basis of simultaneous and successive factor scores and performance of the groups on the Decoding and Comprehension sections of the Elementary Reading Test developed by the Edmonton Public School Board was compared. The means and standard deviations of the four groups are shown in Table 2.

TABLE 2
MEANS AND STANDARD DEVIATIONS OF FOUR GRADE 3 GROUPS
ON READING SCORES

	Decoding		Comprehension	
Hi Sim Hi Succ	50.27	(5.34) ^a	56.40	(12.12)
Hi Sim Lo Succ	52.13	(4.61)	56.44	(9.54)
Lo Sim Hi Succ	48.27	(4.70)	51.73	(10.12)
Lo Sim Lo Succ	47.13	(5.50)	49.07	(10.89)

^a Standard deviations are given in parentheses.

Two-by-two analyses of variance showed significant main effects for simultaneous processing in both Decoding ($F = 7.20$, $df\ 1,56$, $p < .01$) and Comprehension ($F = 4.65$, $df\ 1,56$, $p < .05$) analyses. The main effect for successive processing and the interaction were nonsignificant in both analyses. The results of the analyses of variance were supported by correlations between simultaneous and successive factor scores and reading performance. Simultaneous factor scores correlated significantly with both Decoding ($r = .45$, $p < .001$) and Comprehension ($r = .40$, $p = .001$) performance. Correlations with successive factor scores were nonsignificant.

In order to further investigate the hypothesis that simultaneous processing is especially important at more advanced stages of reading we performed median splits on both comprehension and decoding distributions and carried out correlational analyses in the top and bottom halves of each distribution. Despite the reduced variance in comprehension scores, simultaneous processing correlated significantly ($r = .41$, $p < .05$) with comprehension in the top, but not the bottom, half of the distribution. When the decoding distribution was divided into top and bottom halves the relationship between decoding and simultaneous processing disappeared. From this it can be concluded that simultaneous processing may be necessary for the development of more advanced levels of comprehension skills. The fact that in the present study successive processing related less to reading performance than in the Kirby and Das study may be due either to the different criterion

measures of reading employed or to the fact that the present sample had a somewhat higher mean IQ than the Kirby and Das sample.

In summary, what emerges from these studies is that, among children who are likely to experience difficulty in reading, competence in successive processing is strongly related to reading achievement. However, among normal readers at more advanced levels of reading skills, simultaneous processing is equally, if not more, important in the reading process. These studies suggest the potential of the simultaneous/successive model as a framework for investigating the cognitive processing of children who experience reading difficulties. Understanding of the underlying processing deficits of these children is essential for effective and rationally-based remediation. The simultaneous/successive model is especially useful because of its explicit neuropsychological reference. Luria's observations have specified the cortical locations underlying different types of simultaneous and successive processes. Thus, differences between reading disabled children and normal readers in the relationships between simultaneous and successive dimensions and aspects of linguistic and reading performance can be explicitly related to underlying neurological phenomena. In order to illustrate how the model is relevant in investigating the problems of reading disabilities, we shall review some of the recent research on the cognitive characteristics of RD children.

Cognitive Characteristics of Reading Disabled Children

Researchers are in substantial agreement that a unitary model of reading disability is unlikely to account for the observed phenomena. Rather, there are probably many different types of reading disability with many different causes. Doehring (1976) points out that reading acquisition itself is not a unitary process but rather involves a number of component skills. Consequently, different types of reading disability may be related to difficulties in acquiring different component skills. If the component reading skills are interdependent, however, deficiencies in one or two skills could lead to a general retardation in all reading skills.

Despite the complexity of the issue several broad groups of RD children can be distinguished. Three subgroups of RD children have been identified by several investigators. The first, and largest, subgroup consists of children who show a deficit, or possibly a lag (Satz, 1976), in auditory-temporal processing. Children in this subgroup generally have lower verbal than performance WISC IQ's and are often characterized by speech and language problems. The importance of language-related problems in reading disability can be seen in the fact that 83% of Warrington's (1967) sample of RD children performed more poorly on the verbal scale of the WISC than on the performance scale and a major subgroup of RD children identified by Mattis, French and Rapin (1975) was characterized by problems related to general language acquisition. There is evidence that the linguistic problems of this subgroup may stem from difficulties in successive processing related to neurolinguistic factors associated with the dominant fronto-temporal lobe. Doehring (1968), for example, reported that reading disability was most highly correlated with tasks that required sequential processing; similar relationships between sequential ordering difficulty and reading disability

were also found by Kinsbourne and Warrington (1966). Tallal (1976) has also reported deficiencies in auditory-temporal processing among RD children.

This subgroup of “auditory dyslexics” is contrasted by several investigators (e.g., Myklebust, 1965; Tallal, 1976) with a “visual dyslexic” subgroup comprised of children who have difficulty analyzing the visual-spatial aspects of written language. In Johnson and Myklebust’s (1964) study, 43% of RD children were reported to have visual processing disturbances. However, the proportion of “visual dyslexic” children was considerably less in Warrington’s (1967) study. Doehring (1968) and Ingram (1960) report that this group of RD children with visual processing difficulties were characterized by performance IQ deficits on the WISC, reversals in letters and words and by directional confusion and poor lateralization. In terms of Luria’s model these children are clearly experiencing difficulties in simultaneous processing.

Boder (1973) has suggested that in addition to RD children with auditory-temporal and visual-spatial difficulties there exists a third subgroup which has a more pervasive deficit incorporating difficulties in both auditory and visual processing. Doehring (1968) also distinguished a third group of RD children which was characterized by deficits in both auditory and visual modalities. In addition to *specific* processing deficits, many RD children are characterized by arousal problems (see Das, Leong & Williams, 1977). However, here we are concerned only with specific processing deficits.

Clearly the nature of learning and reading disabilities is multifaceted and studies conducted within the simultaneous-successive framework support the multifaceted nature of these disabilities. Williams (1977), for example, found significant differences between learning disabled and IQ-matched normal children on successive processing tasks and on Figure Copying — a measure of simultaneous processing. Comparison of these learning disabled children with a different control group replicated these findings (Das et al., 1977). Leong (1976) found highly significant differences between RD and normal children on all the simultaneous and successive tasks, despite the fact that groups were matched for IQ. In both these studies factor analyses of simultaneous and successive tasks revealed similar factor patterns in RD and control groups. Das et al. (1977) conclude that although learning disabled and normal children use similar processes in solving the tasks of the battery, the learning disabled children are considerably less efficient in the use of both simultaneous and successive processes.

Satz and his associates (Satz & Sparrow, 1970; Satz & Van Nostrand, 1973) have suggested that developmental dyslexia is a result of a lag in the maturation of the left hemisphere which differentially delays the development of perceptual and conceptual-linguistic abilities as a function of their ontogenetic sequence of development. This theory assumes that perceptual operations are crucial in developing initial reading skills but conceptual-linguistic operations are considerably more important at later stages. The high incidence of WISC Verbal IQ deficiencies associated with reading disability testifies to the importance of conceptual-linguistic factors. Studies of dichotic listening (e.g., Leong, 1976) also provide partial support for the hypothesis of a lag in the development of left hemisphere among reading disabled children. However, as Satz (1976) points out, the finding of a lag in the magnitude of ear asymmetry in disabled readers “has been neither robust nor reliable.”

Rourke (1975, 1976) has disputed the "developmental lag" hypothesis, arguing instead that the cognitive difficulties of RD children constitute a deficit rather than a lag. He points out that the deficit view "differs from the 'developmental lag' position in that there is no necessary expectation that the children who suffer from the deficit(s) will ever catch up with their normal age-mates in those skills required for age-appropriate reading" (1976, pp. 126-127). In support of the deficit position, Rourke (1975) cites the studies of Reitan and his associates (e.g., Reed & Reitan, 1963; Reitan, 1955) who demonstrated a relationship between left hemisphere lesions and selective impairment on the verbal scales of the Wechsler-Bellevue on the one hand, and right hemisphere lesions and selective impairment on the performance scales on the other. The implication is that verbal skills are mediated principally by the left hemisphere and visual-spatial skills by the right hemisphere. Rourke has shown that older learning disabled children (9- to 14-year-old) who exhibit specific patterns of Verbal IQ-Performance IQ discrepancies on the WISC "do behave in a manner that is quite similar to that which would be expected (on the basis of adult data) if they were experiencing the effects of cerebral dysfunction" (1975, p. 916). However, younger learning disabled children (5- to 8-year-old) do not exhibit the same clear cut patterns of abilities and deficits. Thus, the developmental aspects of learning disabilities are crucial (Rourke, 1976).

Thus far, our review of the cognitive characteristics of RD children has indicated the multifaceted nature of the phenomenon. Reading difficulties can result from a variety of processing and arousal problems. However, it is generally agreed that a large proportion of reading difficulties involve problems in general language acquisition possibly deriving from a deficit in successive processing. Several investigators (e.g., Rourke, 1976; Satz, 1976) have emphasized the importance of a developmental perspective since processing requirements of later fluent reading may differ from those of initial reading acquisition. Satz (1976), for example, points out that at more advanced levels, fluent reading performance depends not only on word recognition skills but also on the ability to process and anticipate semantic information. Thus, a relevant question for understanding the nature of reading disability concerns the developmental interrelationships between reading performance, sequencing abilities and semantic or conceptual-linguistic processing.

Reading Disability and the Development of Conceptual-Linguistic Processing

Patel (1976, in press) has recently argued for the centrality of conceptual-linguistic difficulties for some subgroups of reading disabled children. Following Mattis, French and Rapin (1975) Patel points out that one major type of reading disability involves problems related to general language acquisition. He suggests that reading disabled children may have difficulty in processing the relational aspects of words or, in Luria's terms, logico-grammatical relations. In support of this hypothesis he cites Vogel's (1975) finding of a large discrepancy between dyslexic and normal children in the extent to which semantic factors accounted for unique variance in reading comprehension scores. Vogel reported, as did Doehring (1968), that receptive vocabulary correlated significantly with reading comprehension only in

normal readers. In RD children the correlation was close to zero. Vogel points out that this discrepancy is all the more striking in view of the lack of any significant differences between RD and normal readers in receptive vocabulary. She suggests that the RD child "because of his syntactic deficiencies is unable to comprehend the relational aspect of words and therefore is blocked from fully utilizing the semantic information he possesses" (p. 76).

Patel (1976, in press) points out that the semantic-syntactic systems which develop in children around age seven (e.g., Chomsky, 1969; Goodglass, Berko & Hyde, 1970; Kessel, 1970) are similar to the linguistic disorders observed in semantic aphasia by Luria (1970, 1976). Luria has shown that semantic aphasics who have suffered lesions to the parieto-temporo-occipital junction are unable to process the relational aspects of words. They cannot relate the meanings of the words they understand in isolation. For example, anomalous phrases such as "the wife of the sister" would not be noticed by these patients. Processing of spatio-temporal prepositions (e.g., over, before, in front of, in back of, etc.) and passive sentences are also impaired in semantic aphasics. According to Luria, performance of these tasks requires simultaneous processing of logical relations and depends on integrity of the parieto-temporo-occipital junction, which develops around age seven (Luria, 1970).

On the basis of these observations, Patel (1976) suggests that some reading disabled children may not have "acquired the ability to process the relational aspect of words (logico-grammatical relations) due to some difference in their neurolinguistic mechanisms associated with the parieto-temporo-occipital junction" (p. 305). Patel's hypothesis is consistent with the high incidence of verbal IQ deficits among RD children. However, because it is based on Luria's observations, the hypothesis is extremely powerful in terms of specifying brain-behaviour relationships. The hypothesis also raises important research questions regarding the development of reading disabilities which can be posed within the framework of the simultaneous-successive processing model.

For example, to what extent are the hypothesized conceptual-linguistic or logical-grammatical deficits in RD children just one aspect of a more pervasive sequencing deficit, or alternatively, are there two distinct subgroups of RD children (within the more general "language difficulties" subgroup), one suffering from sequencing difficulties and the other from conceptual-linguistic difficulties? Based on Luria's neuropsychological observations, it would be predicted that performance on logical grammatical tasks in normal adults or adolescents would be more closely related to simultaneous than to successive processing. However, at younger age levels when these semantic systems are just beginning to emerge, this relationship may not hold. In fact, the prerequisite skills for the processing of linguistic input are likely to be more dependent on successive than on simultaneous processing. In children who have difficulties in successive processing, this may be especially so. The studies relating simultaneous and successive processing to reading performance in various groups support this hypothesis.

Thus RD children who are characterized by a deficit in successive processing may experience a lag in the differentiation of deeper levels of conceptual-linguistic abilities from more elementary or surface forms of

sequential-linguistic processing. Since fluent reading skills depend heavily on semantically-based linguistic operations this delayed differentiation may explain the significant relationships which have been observed between successive processing and reading performance among RD and other low-achieving groups. However, among normal readers, conceptual-linguistic operations may have become more independent of successive processing with the result that simultaneous processes play a greater role in explaining variance in reading performance.

In this paper our aim has been to show the relevance of the simultaneous-/successive model of cognitive processing for research in reading disabilities. Studies relating simultaneous and successive processing to reading suggest that, among less fluent readers, successive processing accounts for more variance in reading scores than does simultaneous processing. However, among more fluent readers, simultaneous processes assume as much, if not more, importance as successive processes. It is generally agreed that one major form of reading disability involves problems relating to general language acquisition, probably stemming from deficiencies in successive or auditory-temporal processing. It has also been argued that RD children have difficulty in processing the semantic information which is especially important in later fluent reading. Within the framework of the simultaneous-/successive model, we have raised a variety of research questions regarding the developmental interrelationships between reading performance, conceptual-linguistic skills and cognitive processing in both clinical and normal groups of children. We believe that it is only on the basis of this type of research into the underlying processing deficits of disabled readers that rationally-based remediation procedures can be implemented.

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Improving Skill in Applying Mathematical Ideas: A Preliminary Report on the Instructional Gaming Program at Pelham Middle School in Detroit

Performance of 237 students in ten inner-city eighth-grade math classes was assessed under five different sets of instructional conditions to measure their ability to solve two types of problems: (1) those that involve only computation and (2) those that involve not only computation, but also recognition of the relevance of a particular mathematical idea that is indispensable to the solution of the problem. Results indicate that the combination of playing EQUATIONS (an instructional mathematics game) over a two-year period and then working intensively with IMP (Instructional Math Play) Kits for two weeks enables students to apply mathematical ideas (in the sense studied in this experiment) better (at the .0001 level of significance) than any of the other four sets of conditions: (1) playing EQUATIONS alone, (2) playing EQUATIONS and being taught explicitly by a teacher the ideas presented in the IMP Kits, (3) being taught the ideas in an ordinary math class without playing EQUATIONS, and (4) participating in an ordinary math class without explicit teaching of the ideas or playing EQUATIONS. (Mr. Allen is Professor of Law and Research Scientist at the Law School and the Mental Health Research Institute at the University of Michigan; Mrs. Ross is Research Associate at the Mental Health Research Institute.)

Educators working with the EQUATIONS game and associated materials quickly become aware that applying mathematical ideas is much more difficult than merely computing with those ideas. Of course, "applying" an idea is a somewhat vague notion; this preliminary report will be addressed to one aspect of application — namely, recognition that an idea is indispensably relevant to the solution of a problem. Consider the following pair of problems: the first is the C-type (computation), and the second is the R-type (relevance).

1. $6 - (1-3) = \underline{\hspace{1cm}} ? \underline{\hspace{1cm}}$.

<u>A</u>	<u>B</u>	<u>C</u>	<u>Yes</u>	<u>No</u>
2. - - 1 3 6	8	<u> </u>	<u> </u>	<u> </u>

By writing an X in the Yes or No column, indicate whether or not all of the numbers and operations in Column A can be appropriately ordered and grouped (inserting parentheses wherever necessary) to form an expression equal to the number in Column B. If your answer is Yes, write that expression in Column C.

The indispensably relevant idea for solving each of the problems is the subtraction of negative numbers. In the C-type problem, the very statement of the problem clearly and explicitly indicates that subtracting a negative number is involved. That is neither so clearly nor so explicitly cued in the statement of the R-type problem. Those who understand how to subtract negative numbers can easily do the first problem correctly. But many of those who can solve a C-type problem involving subtraction of negative numbers fail to solve a corresponding R-type problem involving negative numbers. In general (in the groups we have studied), about two-thirds of those who solve C-type problems fail to solve a corresponding R-type problem that involves the same idea. The R-type problem is considerably harder than the C-type in this example because the student must recognize from less clear and less explicit cues that subtracting negative numbers is an indispensably relevant idea for solving the problem. “Understanding” an idea in the R-sense (being able to solve R-type problems) includes understanding it in the C-sense, but it also involves something more. R-sense understanding includes the capability of selecting from among a storehouse of ideas understood in the C-sense, those that are indispensably relevant for solving a particular problem. The question to which this study is addressed is whether skills in applying mathematical ideas can be improved by learning procedures which emphasize exposure to situations that are rich in opportunities for such application, at levels of complexity appropriate for each learner.

The EQUATIONS Game and the IMP (Instructional Math Play) Kits

The rules that define the EQUATIONS game establish a problem-generating and problem-solving interaction between small groups of students, an interaction that can easily be controlled to provide a highly individualized learning experience for each of the participants. It is a RAG (Resource Allocation Game) where the resources involved are mathematical ideas. (For details, see Allen, 1972.) The IMP Kits are 16-page pamphlet-simulations of a computer playing EQUATIONS where the computer is programmed to play like a good teacher, rather than like a good player. Each kit presents a lesson on one mathematical idea. For example, in the following situation.

RESOURCES:	+ - - 1 3 3 ()	FORBIDDEN: 2
	=	PERMITTED:
<u>SOLUTION</u>	<u>5</u>	REQUIRED:
	GOAL	

on its turn to move, the computer might move the + from RESOURCES to FORBIDDEN, thus extinguishing the SOLUTION $(3 + 3) - 1$ and presenting the learner, in effect, with the question:

Is it still possible (after the + is FORBIDDEN) to construct an expression equal to the GOAL of 5 from the remaining RESOURCES?

If the learner by challenging the computer's move, in effect, answers "NO," then the computer will direct the learner to a comment that teaches a lesson in the subtraction of negative numbers:

Your challenge that all SOLUTIONS have been extinguished is incorrect. The SOLUTION $3 - (1-3)$ is still possible. Notice how a pair of minus signs can be used to give the effect of addition. Since $3-5 = -2$ and $3 - -2 = 5$, the GOAL can be achieved even though the + is FORBIDDEN. Go on to the next IMP Kit.

There are at present five versions of each of 21 ideas, or a total of 105 kits. The first 21 of these IMP Kits have been published and are available to those interested. (For details, see Allen & Ross, 1975.)

Method

Subjects

All of the students in each of ten of the fourteen eighth-grade classes in mathematics at Pelham Middle School participated in the study. The ten classes were chosen to include all four of the classes in which the EQUATIONS game had been used during the prior two years as part of the regular instructional program in mathematics and two other classes of each of the three participating teachers. Pretest and/or posttest data were collected on 237 of the students enrolled in these ten classes.

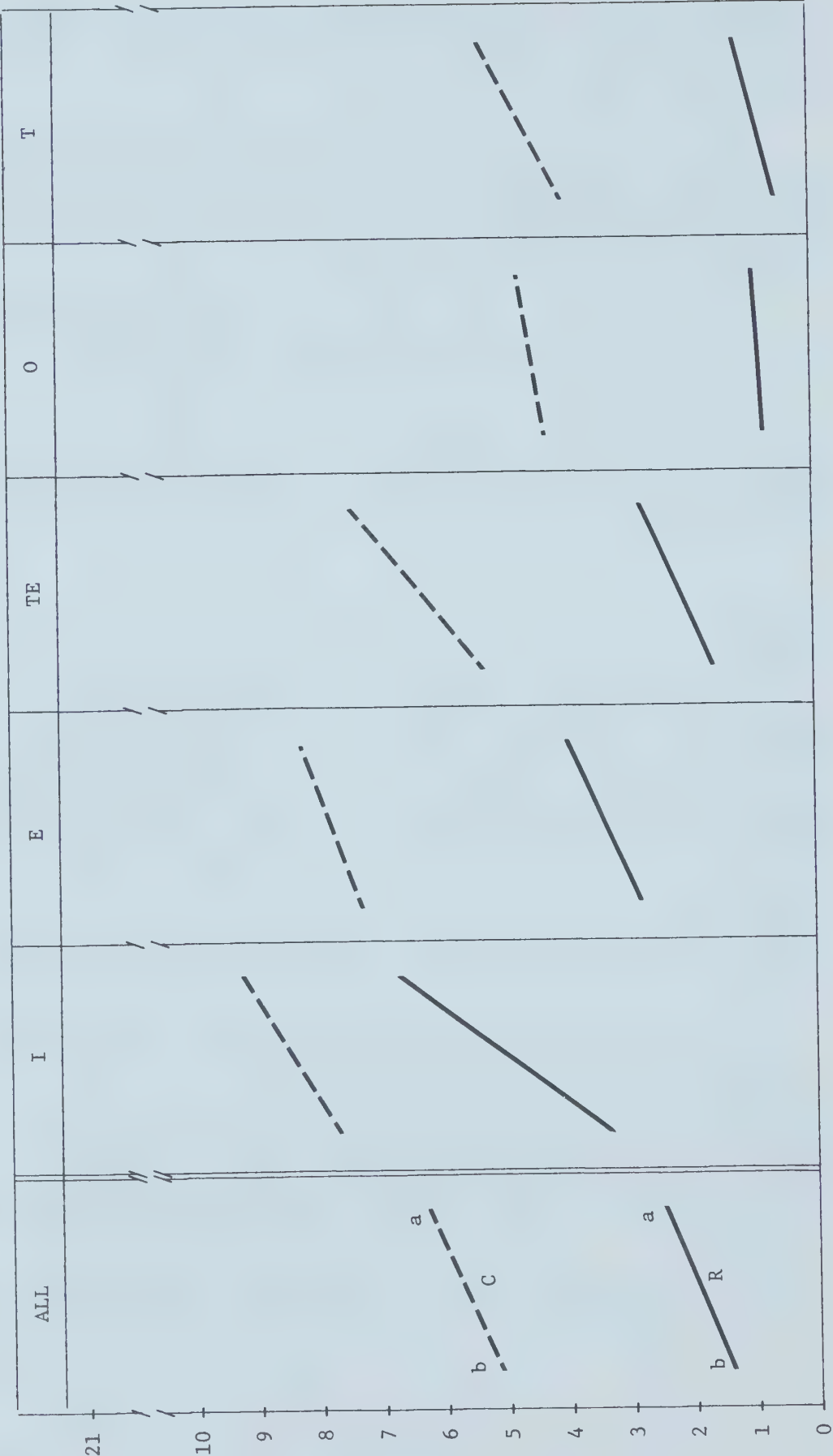
Experimental Treatments

The following five different sets of experimental conditions were represented in the ten classes:

- I an EQUATIONS class in which the IMP Kits were used in five class periods during the two-week experiment and the regular once-a-week EQUATIONS tournament was continued;
- E an EQUATIONS class in which the game was played for the five class periods without any explicit teaching of the 21 IMP Kit ideas;
- TE two EQUATIONS classes in which the game was played for five class periods and the teachers explicitly taught the 21 ideas presented in the IMP Kits;
- O three non-EQUATIONS classes in which the ordinary classroom procedure was continued without change with no special attention given to the 21 IMP Kit ideas; and
- T three non-EQUATIONS classes in which the teachers explicitly taught the 21 IMP Kit ideas for five class periods.

The set of conditions of greatest interest to the researchers was that of the I group in which students individually played through the IMP Kits, completing as many of the set of 105 as they could in the five periods. Before

Figure 1. Mathematics pretest and posttest scores on C Tests and R Tests of five experimental groups of eighth-grade classes, Pelham Middle School, Detroit, 1974.



	b	a	a - b	b	a	a - b	b	a	a - b	b	a	a - b	b	a	a - b		
C	206	202	188	23	23	23	18	17	17	46	44	44	58	61	50		
	N																
	$\bar{X}$	5.10	6.32	1.26	7.70	9.26	1.57	7.39	8.35	0.82	5.33	7.48	2.07	4.31	5.32		
	Sx	2.50	3.23	2.36	2.29	2.75	2.39	2.70	2.87	2.40	2.33	3.69	2.43	1.81	2.61		
Signif.			.0001			.005			ns			.0001			.0001		
R	207	202	190	23	23	23	17	17	16	46	44	44	60	60	51		
	N																
	$\bar{X}$	1.40	2.43	1.03	3.39	6.78	3.40	2.88	4.12	1.00	1.65	2.84	1.11	0.83	1.41		
	Sx	1.70	2.79	1.81	1.56	3.16	2.27	2.00	2.32	1.93	1.83	2.62	1.79	1.15	1.82		
Signif.			.0001			.0001			ns			.0005			.0001		
C - R	202	198	181	23	23	23	17	17	16	46	44	44	58	59	43		
	N																
	$\bar{X}$	3.73	3.93	0.20	4.30	2.48	-1.83	4.59	4.24	-0.19	3.67	4.64	0.95	3.45	3.98		
	Sx	1.88	2.22	2.60	1.99	1.86	2.35	2.83	2.17	3.74	1.71	2.51	2.56	1.62	2.23		
Signif.			ns			.005			ns			.05			ns		
	ALL			I			E			TE			O			T	

this group started on the IMP Kits, one class period was devoted to teaching members of the class how to use the kits.

Dependent Variables

The effects of the various sets of experimental conditions were measured by two different forms of a pair of specially-constructed tests targeted at the 21 mathematical ideas presented in the IMP Kits. The first of the pair of tests is called a C test; it contains only C-type items. The second test is called an R test; it contains only R-type items. Two different forms of the C test were used (Form C and Form D), as well as two different forms of the R test (Form E and Form F). In each of the ten classes in which these tests were administered, the students were divided into eight groups — G1, G2, . . . G8. Each student received a C test and R test as pretests, and each received alternative forms of the two tests as posttests as follows:

	Order of Administration	Groups							
		G1	G2	G3	G4	G5	G6	G7	G8
Pretest	1	C	C	E	F	D	D	E	F
	2	E	F	C	C	E	F	D	D
Posttest	1	F	E	D	D	F	E	C	C
	2	D	D	F	E	C	C	F	E

Using Ca (after) to denote the score on the C posttest and Cb (before) to denote the C pretest score (and similarly for the R pretests and posttests), outcome measures of three dependent variables can be specified as follows:

- | | |
|----------------------|--|
| 1. Ca-Cb | Increase in performance on C test |
| 2. Ra-Rb | Increase in performance on R test |
| 3. (Ca-Ra) - (Cb-Rb) | Decrease in difference in performance on C test and R test |

Results

The scores for each of the five experimental groups, summarized in Figure 1, were significantly higher (at the .0001 level) on the C test than on the R test both on pretests and on posttests. The mean pretest score for all students on the C test was 5.10, while for the R test it was 1.40 (maximum score = 21), a ratio of about 3.6 to 1. On the posttests the ratio decreased to 2.6 to 1 with mean scores of 6.32 and 2.43, respectively.

Three of the experimental groups had significant differences between pretest and posttest scores on the C test (measured by Ca-Cb). The IMP Kit group (I) had a mean pretest of 7.70 and 9.26 on the posttest, significantly higher at the .001 level, and the groups that were explicitly taught the 21 ideas (TE and T) went from 5.33 to 7.48 and from 4.02 to 5.32, respectively, significantly higher on the posttest at the .0001 level.

The same three experimental groups had significant differences between pretest and posttest scores on the R test (measured by Ra-Rb). The IMP Kit group and the T group were significantly higher on the posttest (.0001) with mean pretest to posttest scores of 3.39 to 6.78 and 0.59 to 1.41, respectively, whereas the TE group was significantly higher at the .0005 level with scores of 1.65 to 2.84.

Only two of the experimental groups showed significant changes in the gap between C-sense understanding and R-sense understanding from the pretests to the posttests [as measured by (Ca-Ra) - (Cb-Rb)]. The IMP Kit group achieved a 1.83 reduction in its CR Gap, significant at the .005 level, in moving from a pretest gap of 4.30 to a posttest gap of 2.48. On the other hand, the T group increased its CR Gap by 0.95, significant at the .05 level, with a pretest gap of 3.67 and a posttest gap of 4.64.

In comparing the test scores of the experimental groups with each other, only those pairs in the total collection that qualify by the highly conservative Scheffé procedure (see Winer, 1971) at the .05 level of significance are reported as being significantly different. The results of the between-group comparisons are summarized in Figure 2.

Tests	Pretest					Posttest					Pretest - Posttest				
C	Significance Lines and Levels					Significance Lines and Levels					Significance Lines and Levels				
	T	O	TE	E	I	O	T	TE	E	I	O	E	T	I	TE
	T	ns	.0005	.0001	.0001	O	ns	.0001	.0001	.0001	O	ns	ns	ns	.005
	O		ns	.0001	.0001	T		.0005	.0001	.0001	E		ns	ns	ns
	TE			.001	.0001	TE			ns	ns	T			ns	ns
	E				ns	E				ns	I				ns
R	Significance Lines and Levels					Significance Lines and Levels					Significance Lines and Levels				
	T	O	TE	E	I	O	T	TE	E	I	O	T	E	TE	I
	T	ns	.0005	.0001	.0001	O	ns	.0001	.0001	.0001	O	ns	ns	.001	.0001
	O		ns	.0001	.0001	T		.001	.0001	.0001	T		ns	ns	.0001
	TE			ns	.0001	TE			ns	.0001	E			ns	.0001
	E				ns	E				.0001	TE				.0001
C - R	Significance Lines and Levels					Significance Lines and Levels					Significance Lines and Levels				
	E	I	TE	T	O	TE	E	T	O	I	TE	T	O	E	I
	E	ns	ns	ns	ns	TE	ns	ns	ns	.0001	TE	ns	ns	ns	.0001
	I		ns	ns	ns	E		ns	ns	ns	T		ns	ns	.0005
	TE			ns	ns	T			ns	ns	O			ns	.0005
	T				ns	O				ns	E				ns
KEY															
Treatments:															
I IMP Kits															
E EQUATIONS															
TE Taught 21 Ideas, EQUATIONS															
O Ordinary classroom activities															
T Taught 21 Ideas															

Figure 2. Significance levels of pairs of sets of conditions that significantly differ from each other on test scores. (The only pairs of sets of conditions shown in this table as significantly different from each other are those in the collection of pairs that satisfy the highly conservative Scheffé procedure at the .05 level.)

On the pretest scores seven of the pairs of groups were significantly different on the C tests, six pairs were different on the R tests, but none were significantly different on the amount of the CR Gap. The significance lines written over the names of each of the experimental groups in Figure 2 should be interpreted as follows:

- 1. Groups whose names *do not* appear under a common line *do* differ significantly from each other;
- 2. Those whose names *do* appear under a common line *do not* differ significantly from each other.

Hence, on C pretest scores the IMP Kit group was significantly higher than the TE, O, and T groups (at the .0001 level); the E group was higher (.001) than the TE group and higher (.0001) than the O and T groups; and the TE group was higher (.0005) than the T group.

Pre C			TE		
	T	O		E	I

On the R pretest scores the IMP Kit group was again significantly higher than the TE, O, and T groups (.0001); the E group, higher than the O and T groups (.0001); and the TE group, higher than the T group (.0005).

Pre R			TE		
	T	O		E	I

The lack of any significant difference on the pretest scores between any of the pairs of experimental groups with respect to the amount of CR Gap is indicated by the appearance of all of the names of the groups under a common line.

Pre C-R					
	E	I	TE	T	O

On the posttest scores one less pair of groups was different on the C test; one more pair, different on the R test; and there emerged at this time a pair different with respect to the CR Gap. On the C posttest scores both the IMP Kit group and the E group were significantly higher (.0001) than the T and O groups, and the TE group was higher (.0005) than the T group as well as higher (.0001) than the O group. On the R posttest scores, the IMP Kit group was significantly higher (.0001) than every one of the other groups; the E group, higher (.0001) than the T and O groups; and the TE group, higher (.001) than the T group and higher (.0001) than the O group. With respect to the amount of CR Gap on posttest scores, the one pair significantly different resulted primarily from the large pretest-posttest improvement in the R test score of the IMP Kit group; thus the CR Gap of the IMP Kit group turned out to be significantly smaller (.0001) than that of the TE group.

On the improvement indicated by the difference between posttest and pretest scores, the IMP Kit group clearly emerges as the group that achieved the greatest improvement. The only other group that was significantly higher than any of the other groups on any of the three improvement measures was the TE group. In improvement on C test scores only one pair of groups was significantly different: the improvement of the TE group was greater (.005)

than that of the O group. In improvement on R test scores the IMP Kit group was significantly greater (.0001) than every one of the other groups, and the TE group was greater (.001) than the O group. With respect to what is probably the most important measure of all — the extent of the improvement in reducing the CR Gap — the IMP Kit group is the only group significantly better than any of the other groups. It deserves emphasis that the IMP Kit group turned out significantly better on this measure than every other group except the E group — and better than the E group, although not significantly so. The improvement of the IMP Kit group in reducing the CR Gap was greater (.0005) than that of the O and T groups and greater (.0001) than that of the TE group.

The significant differences on the C pretest and R pretest scores among the experimental groups deserve close scrutiny. Most (10 of the 13) of the differences are differences between EQUATIONS groups and nonEQUATIONS groups, and nearly half (6 of 13) are differences between the IMP Kit group and other groups. This raises the question as to whether the EQUATIONS groups generally and the IMP Kit group in particular were not simply more capable students at the beginning of the experiment. If so, perhaps it is not surprising that they improved more in learning to apply mathematical ideas during the two-week experiment. The next question is: Given that the students in the EQUATIONS groups were more capable at the end of their eighth-grade year when the experiment was conducted, were they also more capable two years earlier when they entered seventh grade?

School records indicate that the Stanford Arithmetic Test — Advanced (computation) was administered to all entering seventh-grade classes two years earlier and that 112 of the students in this study participated. From the scores recorded for this sample of the 237 students in the study for whom there is this indication of mathematical capability at the time of entry to the seventh grade, it appears that there was no significant difference between any of the pairs of the experimental groups at that time. In particular, there was no significant difference between the IMP Kit group and any of the other groups. Also, when data for the three EQUATIONS groups are combined and those for the two nonEQUATIONS groups are also combined, there is no significant difference in mean scores between the EQUATIONS groups and the nonEQUATIONS groups. The data are summarized in Table 1.

TABLE 1
MATHEMATICAL CAPABILITIES TWO YEARS EARLIER: SCORES ON
STANFORD ARITHMETIC TEST—ADVANCED (COMPUTATION)^a

Group	All	I	E	TE	O	T	EQ	nEQ
N	112	22	14	25	23	28	61	51
$\bar{X}$	46.54	48.95	52.07	44.36	44.96	43.50	47.79	44.16
Sx	11.48	9.59	11.06	10.93	10.05	13.70	10.78	12.20

^a Administered in September, 1972, for 112 of the 237 students in this study enrolled in Pelham Middle School eighth-grade classes in May, 1974.

The EQUATIONS and nonEQUATIONS groups were quite different two school years later when this experiment was undertaken, as was the IMP Kit group compared to all other groups except the E group. On the C pretest the EQUATIONS groups had a mean score of 6.38, significantly higher at the .0001 level than the 4.16 mean score of the nonEQUATIONS groups. On the R pretest the EQUATIONS groups were also significantly higher (.0001); the mean scores were 2.36 to 0.71. With respect to the CR Gap the 0.50 difference between the means of the two groups was not significant. The data for the EQUATIONS groups compared to the nonEQUATIONS groups are summarized in Table 2. The data for the other comparisons are in Figure 2.

TABLE 2
COMPARISON OF EQUATIONS AND NONEQUATIONS GROUPS

	Pretest b		Posttest a		Posttest-Pretest a - b	
	EQ	nEQ	EQ	nEQ	EQ	nEQ
<u>C Test</u>						
N	87	119	84	118	84	104
$\bar{X}$	6.38	4.16	8.14	5.02	1.68	0.91
Sx	2.62	1.94	3.35	2.41	2.44	2.24
Signif.	.0001		.0001		.05	
<u>R Test</u>						
N	86	121	84	118	83	107
$\bar{X}$	2.36	0.71	4.18	1.18	1.72	0.50
Sx	1.94	1.08	3.17	1.55	2.20	1.19
Signif.	.0001		.0001		.0001	
<u>C-R</u>						
N	86	116	84	114	83	98
$\bar{X}$	4.02	3.52	3.96	3.91	-0.04	0.41
Sx	2.06	1.72	2.44	2.06	2.99	2.22
Signif.	ns (.0589)		ns		ns	

Discussion

This study provides strong support for the proposition that skills in applying mathematical ideas can be improved by learning procedures that are rich in opportunities for such application at appropriate levels of complexity for each student. Interpreted most favourably, the results show that the combination of playing EQUATIONS over a two-year period and then working intensively with the IMP Kits for two weeks enables students to apply mathematical ideas (in the sense studied in this experiment) better than any of the other four sets of conditions do: better than just playing EQUATIONS alone, better than playing EQUATIONS and being taught explicitly by the teacher the 21 ideas presented in the IMP Kits, better than being taught the 21 ideas in an ordinary traditional mathematics class, and better than being in an ordinary traditional class without any special teaching of the ideas — and, furthermore, better in each case by a highly conservative test at an extreme level of significance (.0001). It should be acknowledged immediately that there are some questions with respect to this

most favourable interpretation which require further investigation. At the start of the experiment the IMP Kit group was clearly performing at a higher level of achievement than were the other groups. This superior performance seems linked to their two-year experience in playing EQUATIONS. The available evidence indicates that the EQUATIONS and nonEQUATIONS groups were not different upon their entry to the seventh grade, but that after two years of different experience with respect to whether or not they played EQUATIONS, the EQUATIONS group was significantly better in both computing with and applying these 21 mathematical ideas. The emphasis of the IMP Kit experience is clearly in the direction of improving skills in applying mathematical ideas, although it does improve both computing and applying. In terms of reducing the difference between understanding a mathematical idea in the sense of computing correctly with it and understanding it in the sense of being able to apply it in a context where it must be recognized to be relevant (the CR Gap), playing through the IMP Kits clearly is more effective than any of the other methods tried in this experiment (except possibly playing EQUATIONS alone, where the effect is in the right direction but is not significant).

For classrooms in which learning to apply mathematical ideas is still a problem, the implications of the findings of this study are obvious: learning environments so structured are effective — and should be used.

In an earlier study (Allen & Main, 1976), the objectives of designing structured learning environments of the type studied here were described as the enhancement of both the affective and cognitive dimensions. It was shown there that attitude as measured by absenteeism was profoundly affected through the use of such structured learning environments, and the prediction was ventured that in intelligent hands the achievement of knowledge should be, too. In this inner-city school in Detroit the learning structure we are designing has been in such hands. We still need to learn more, but the efforts there have advanced our understanding one solid step along the way.

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Some Effects of Distractions in Nonverbal Mathematical Problems

The central purpose of this study was to investigate the effects of distractions in nonverbal problems on the problem-solving behaviour and performance of young children. Ten groups, matched on sex and ability, were selected from each of grades 1-3 in six schools. At each grade level, each group was randomly assigned to one of two partitive division problems in one of five problem settings representing different types and amounts of distraction. Two-thirds of the 360 subjects were distracted by irrelevant spatial-numerical or color-attribute cues. Both the problem setting and the degree of attention to distractions had a significant effect on problem-solving behaviour and performance. Distracted subjects appeared to identify and attempt a different problem from the one assigned. (Dr. Bana is Senior Lecturer in Mathematics Education at Mount Lawley College, Perth, Australia; Dr. Nelson is Professor in the Department of Elementary Education, The University of Alberta.)

Problem solving has always been an important component of the school mathematics program. Although the research in this area has been extensive, it has been directed almost exclusively at verbal problems and still leaves many questions unanswered (Suydam, 1976). At the University of Alberta a research project was undertaken to study the behaviours of children aged 3 to 9 years in solving nonverbal problems (Nelson & Sawada, 1975). Some of the findings of this project have now been reported (Bourgeois, 1976; Little, 1976; Nelson & Kieren, 1976; Bourgeois & Nelson, 1977). As reported by Bourgeois and by Bourgeois and Nelson, the younger children were often distracted by irrelevancies in the problem setting.

Bana and Nelson (in press) undertook an exploratory study to establish some bases for a more detailed investigation of the role of distractions in nonverbal problems. In the exploratory study four groups of eight children, matched on sex and ability, were selected from each of grades 1-3 in a large

elementary school in Edmonton. At each grade level each group attempted a nonverbal partitive division problem embodied in one of four settings representing different types or amounts of distraction. It was found that both grade and problem setting had a significant effect on problem-solving performance. The extent of attention to distractions was dependent on the problem setting and significantly affected performance.

A number of studies have shown that the inclusion of irrelevancies in word problems increases problem difficulty (Biegen, 1971; Jerman & Rees, 1972; Blakenship & Lovitt, 1976). Irrelevant data also appears to hinder concept formation with pictorial material, as shown by Mansfield (1970). The Piagetian and related studies provide numerous instances where young children's centrations on irrelevant perceptual cues in concrete and pictorial materials prevent them from developing specific concepts. For example, children who failed to conserve numerosness often focused on the configuration of a set of objects and ignored the number of objects (Piaget, 1952). Gelman (1969) and Bryant (1974) found that preschool children succeeded in conserving number after being trained to ignore irrelevant cues. Although there is some evidence that young children are also distracted in nonverbal mathematical problems, no studies have systematically investigated the role of distractions in such problems. The major purposes of the current study were to determine the effects of distractions in nonverbal problems on the problem-solving behaviour and performance of young children in grades 1-3, and investigate the relationships of distractedness (whether a child was distracted or not) to sex, ability, conceptual tempo, grade, problem difficulty, and problem setting.

Method

Two nonverbal partitive division problems of different difficulty levels were devised for the study, as follows:

1. In Problem A 12 cars were to be partitioned into three equivalent sets and the subject was required to give the number in each set.
2. Problem B was the same as Problem A except that there were 13 cars, which therefore involved a remainder.

Each of these problems was embodied in five problem settings representing different types and amounts of distraction, as follows:

1. Twelve (or 13) yellow toy cars of similar size and shape, together with three identical yellow toy trucks, each of which could take up to six cars (minimal distraction), as illustrated in Figure 1.
2. Cars and trucks as in (1) with a roadway for the trucks, a parking area for the cars, a building, a loading ramp, and three toy men — one near the ramp, and one on the back of each of the first two trucks in line (situational distraction), as in Figure 2.
3. A blue, a yellow, and a red truck, together with three blue, four yellow, and five (or six) red cars, all objects of the same shapes and sizes as before (color-attribute distraction), as in Figure 3.
4. Cars and trucks as in (1), but with six bays marked on the back of each truck (spatial-numerical distraction), as in Figure 4.
5. All the distractions of (2), (3), and (4) combined (maximum distraction), as in Figure 5.

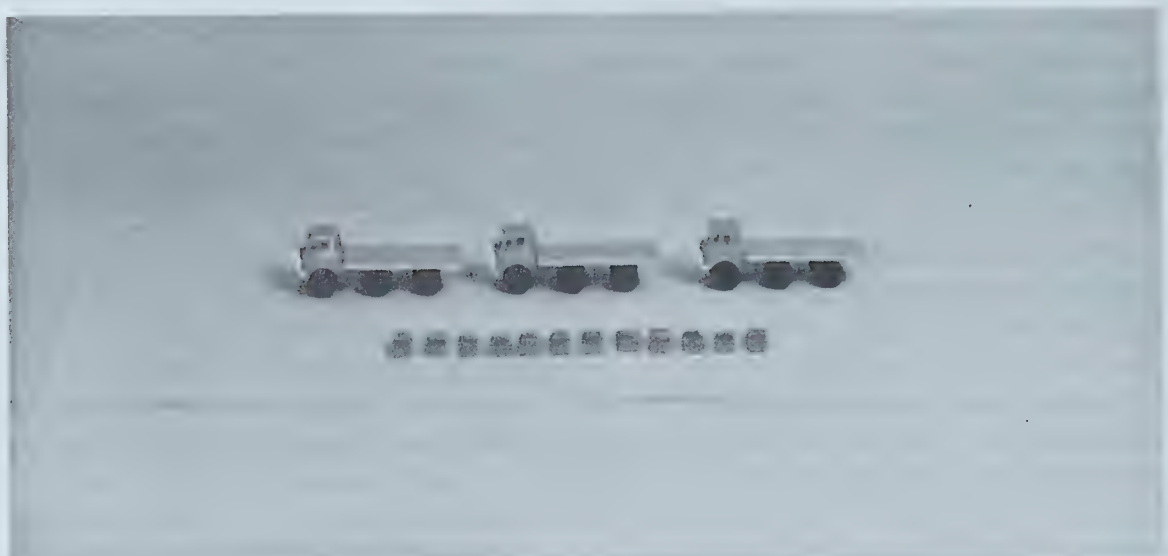


Figure 1. First problem setting.



Figure 2. Second problem setting.

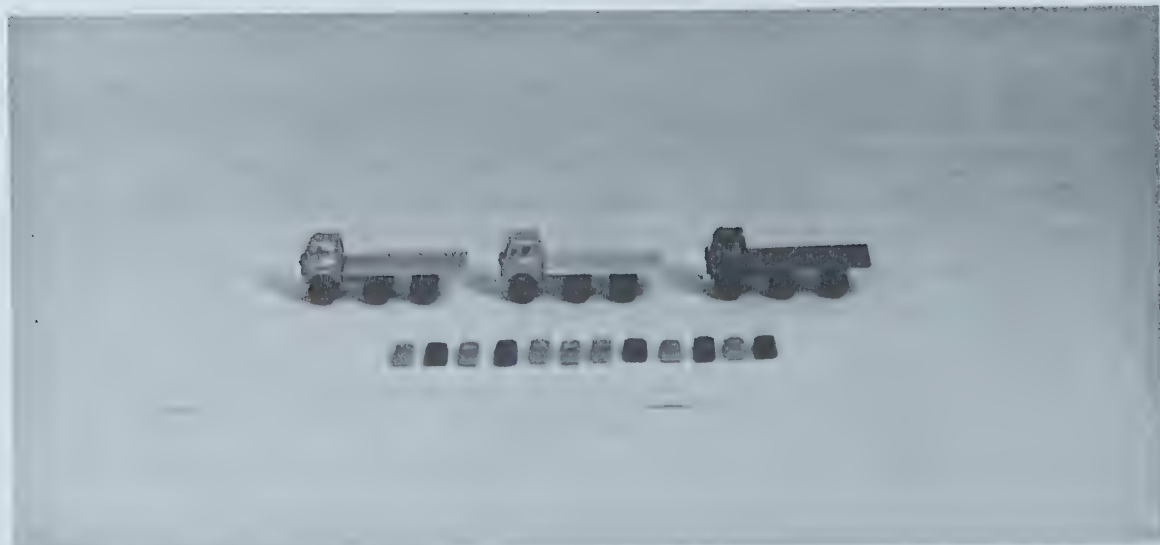


Figure 3. Third problem setting.

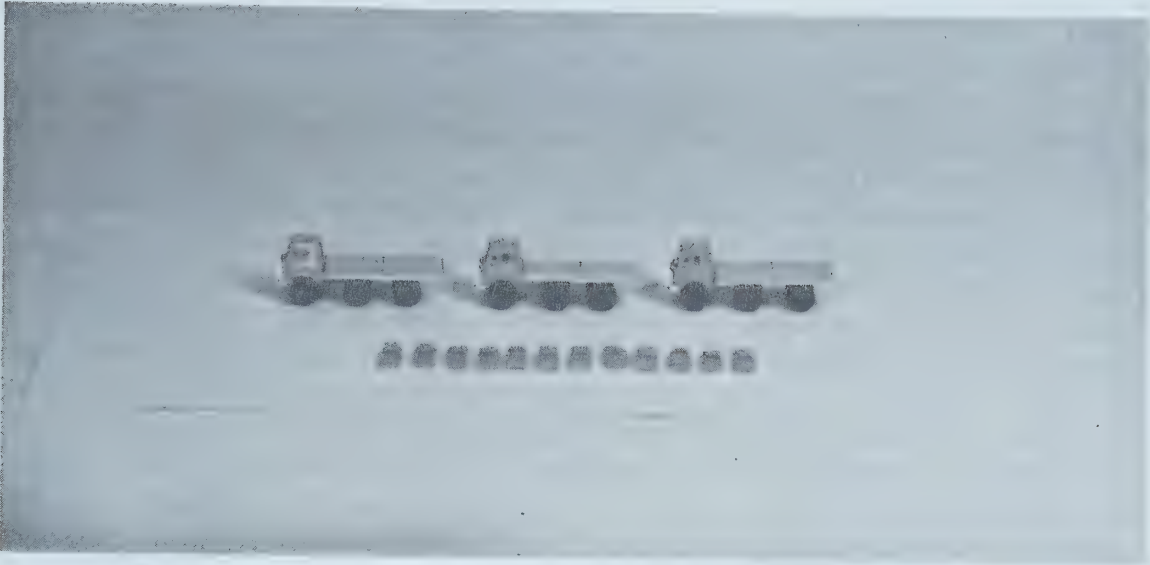


Figure 4. Fourth problem setting.

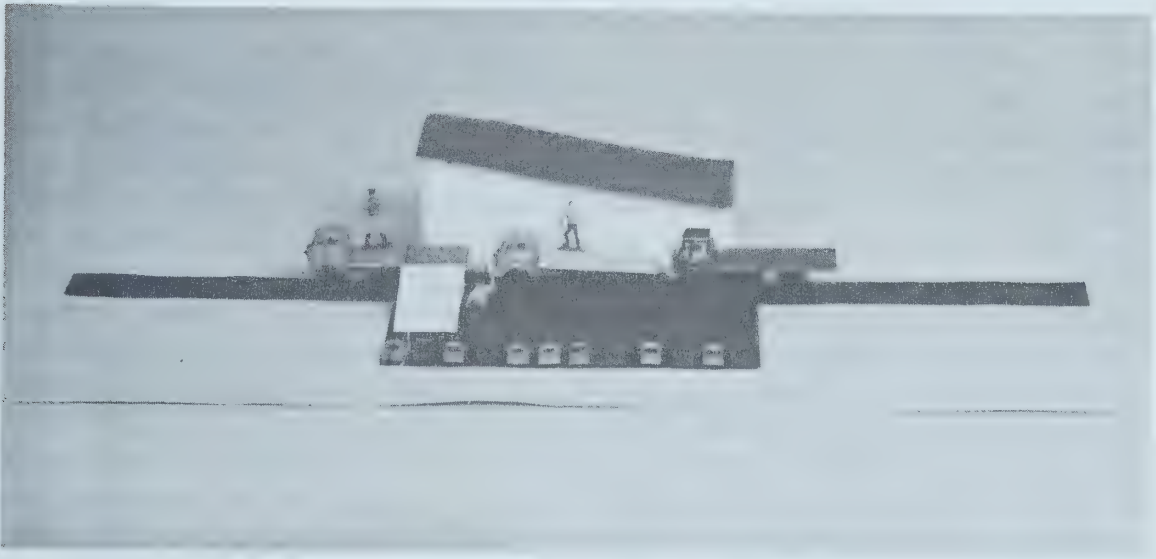


Figure 5. Fifth problem setting.

The types of distractions used here were based on the findings of Bourgeois (1976). In the exploratory study, Problem A was assigned to subjects in each of the first four settings (Bana & Nelson, in press).

The data for the main study were collected in November and December, 1976. Six schools were chosen from within the Edmonton Public School system so as to represent, as far as practicable, the population of first-, second-, and third-graders in the system. Stratified random sampling procedures, based on sex and Metropolitan Readiness Test percentile ranks, were used to select ten matched groups from the grade 1 pupils in these schools. Each group consisted of three girls and three boys in the high ability range, and three girls and three boys in the low ability range. Ten matched groups were selected from each of grades 2 and 3 in the same way, except that percentile ranks on a standardized mathematics test of the Edmonton Public School Board were used as the criterion for ability.

At each grade level each group was randomly assigned to either Problem

A or Problem B in one of the five settings described above. Each of the 360 subjects attempted the problem individually with the experimenter (*E*). The subject (*S*) was shown the materials, then *E* stated: "We have to load as many of those cars as we can onto the three trucks, but we must put the same number of cars on every truck. How many of those cars will be on each truck?" *E* repeated the problem question, and did so again if *S* was still unsure, asked any questions, or seemed uncertain how to respond. When *S* gave a solution *E* asked, "Are you sure that's right?" This question was repeated for each solution given, until *S* either confirmed a solution or indicated the unlikelihood of any further progress. Then *E* asked a question of the form, "How did you know there would be . . . on each truck?" Thereafter, the structure of the interview varied according to the subject's actions and verbalizations. The major objectives were to get at the thought processes used in attempting the problem, and to determine whether or not the subject was distracted. Verbalizations were recorded on audio-tape, and all observed nonverbal behaviors were noted on data cards. Samples of interview transcripts may be found in Bana (1977).

Each subject was awarded a score of either zero, one, two, or three on the problem-solving task. One point was awarded if the subject's first solution was correct. A second point was given if the subject confirmed the correct solution and demonstrated confidence in it, and a third point was allocated if a valid process was used in attempting the problem. The time taken for each subject to give the first response was noted and, based on a median split, was classified on the dimension of conceptual tempo as being either a fast (impulsive) or a slow (reflective) responder. A five-way analysis of variance was carried out to determine the main effects of grade, sex, ability, problem difficulty, and problem setting on problem-solving performance, and also any interaction effects. Chi-square goodness-of-fit tests, and tests for differences between means or proportions were used to investigate other relationships. An independent coder was employed to carry out a reliability check on the coded data. Based on a stratified random sample of 30 students, the coefficient of agreement was 0.94. A specific comparison of the scores awarded was also undertaken. Only two of the 30 scores differed from those of the experimenter, thus giving a reliability coefficient of 0.93. Based on these results, experimenter reliability was considered to be adequate.

Results

The subjects exhibited a wide range of problem-solving behaviours which, in many cases, were influenced by the problem setting. Thirty-two percent of the subjects attempted the problem by loading cars on the trucks, while the remainder gave verbal responses without handling the material. Manipulations were less frequent in the fourth and fifth problem settings than in any of the other three settings. The tendency to manipulate the objects decreased only slightly through the three grades and the differences were not significant.

The more common arrangements of cars attempted, and the rationales behind these are given in Table 1. An arrangement such as 3,4,5 indicates that the subject said there would be, or actually put three cars on the first truck, four cars on the second, and five cars on the third truck in line. Only 36 percent of the subjects used a valid process in attempting the problem. Of

TABLE 1
FREQUENCY DISTRIBUTION OF RATIONALES FOR SPECIFIC
ARRANGEMENTS OF CARS

Rationale	Arrangement												
	3	3	3	4	5	5	5	6	6	6	9	Other Total	Other Total
	3	4	4	4	5	5	5	6	6	6	9		
	3	5	6	4	2	3	5	0	1	6	9		
Division or Multiplication	-	-	-	4	-	-	-	-	-	-	-	-	4
Distribution of Cars One by One	-	-	-	11	-	-	-	-	-	-	-	-	11
Trial of Equivalent Sets	36	-	-	109	7	3	4	1	1	-	-	24	185
Guess	3	-	-	3	-	-	2	-	-	1	1	2	12
Same Number of Cars as Trucks	6	-	-	-	-	-	-	-	-	-	-	-	6
Spatial-Numerical Cues:													
(a) Amount of Room	5	-	-	9	4	9	7	8	7	9	7	36	101
(b) The Marked Bays	-	-	-	-	2	2	10	10	6	87	-	12	129
Color-Attribute Cues:													
(a) Cars of Each Color	-	12	9	2	-	-	-	-	-	-	-	3	26
(b) Cars of a Particular Color	7	-	-	3	-	-	-	-	-	3	-	-	13
Induced Spatial-Numerical Cue	-	-	-	6	1	-	6	2	1	7	2	2	27
Induced Color-Attribute Cue	2	-	-	2	-	-	-	-	-	-	-	-	4
No Explanation	6	-	-	2	-	-	1	-	-	3	-	1	13
Other	-	-	-	-	-	-	-	-	-	-	-	3	3
Total	65	12	9	151	14	14	30	21	15	110	10	83	534*

* Some subjects attempted more than one arrangement.

these, only 15 subjects employed a systematic process; the remainder used trial and error methods. As can be seen in Table 1, most of the subjects who used an invalid process based their solutions on irrelevant spatial-numerical cues. Color-attribute cues were also used as rationales for solution strategies. Some subjects stated that they obtained a solution by guessing, while others did not give any explanation for their particular arrangements of cars.

The frequencies of distracted subjects in each problem setting are given in Table 2. Spatial-numerical cues distracted 208 subjects. In the fourth and fifth settings the majority of the subjects said there would be six cars per truck because there were six bays marked on each truck. In the first three settings, where the trucks were unmarked, some subjects based their response on the amount of room on the trucks. However, the spatial-numerical distraction was not as strong in these cases. Manipulative solvers who were distracted by the amount of room or the number of bays would fill the first two trucks and put the remaining cars (if any) on the third truck. This accounted for the arrangements 5,5,2 or 6,6,0 for Problem A, and 5,5,3 or 6,6,1 for Problem B. The men on the first two trucks in the second and fifth settings distracted some subjects, but only in a spatial-numerical sense since each man was considered to occupy a space, which meant that one car fewer could be put on those trucks. The arrangements 3,4,5 for Problem A and 3,4,6 for Problem B were based on the numbers of blue, yellow, and red cars respectively, and thus occurred in the third and fifth settings. Some subjects based their arrangements on cars of a particular color; for example, seven subjects said there would be three cars on each truck because there were only three blue cars for the blue truck. There were 42 cases where subjects were distracted by

TABLE 2
FREQUENCY DISTRIBUTION OF SUBJECTS DISTRACTED IN
EACH PROBLEM SETTING

Problem Setting	Distraction			
	Spatial-Numerical	Color-Attribute	Other	Total*
1	28	—	—	28
2	36	—	—	36
3	18	32	—	46
4	64	—	—	64
5	62	10	1	64
1-5	208	42	1	238

* Totals do not always correspond to row frequencies since some subjects attended to more than one type of distraction.

color-attribute cues and set out to match cars and trucks by color. Color was a stronger distraction than the spatial-numerical cue in the third setting. However, in the fifth problem setting, with the marked bays, the reverse was true.

Some subjects overcame distractions; that is, they were distracted by an irrelevant cue initially but then abandoned this as a means for solving the problem. Fifty-seven subjects overcame at least one distraction as shown in Table 3. The proportion of distracted subjects decreased with an increase in grade level, and the difference between observed and expected frequencies was significant ($\chi^2 = 11.96, p < 0.005$). Subjects often gave no explanation for their attention to irrelevancies, particularly when they used a spatial-numerical cue. The most common reason given in this case was that there

TABLE 3
OBSERVED AND EXPECTED FREQUENCIES OF DISTRACTED SUBJECTS
IN EACH GRADE WHO SUCCEEDED OR FAILED IN
OVERCOMING DISTRACTIONS

Grade	Overcame at Least One Distraction	Failed to Overcome Any Distractions	Total Distracted
1	12 (20.6)	74 (65.4)	86
2	19 (19.9)	64 (63.1)	83
3	26 (16.5)	43 (52.5)	69
1-3	57	181	238

were enough cars to fill all the trucks. For the subjects who were distracted by color, the prevalent explanation was in terms of aesthetics. When asked why they would match cars and trucks by color, children often replied that this would look “nice,” “pretty,” “good,” “better,” or “neat.” In some cases where a subject did not give an explanation for a particular response, a distraction was induced inadvertently by the experimenter’s questions. For example, if a subject said there would be six cars on each truck the experimenter may have asked: “Did you think about filling each truck?” If the subject replied in the affirmative this was recorded as an “induced” spatial-numerical distraction, but there was no way of interpreting the information gained in this way.

Distractedness has a very significant effect on problem-solving performance, as revealed by the difference between means ($z = 9.69, p < 0.0002$). The mean score for the 238 distracted subjects was 0.58, while the mean for the remaining 122 subjects was 1.88. The mean scores for each grade on the two problems are given in Table 4. Scores were comparatively low in the fourth and fifth problem settings. A five-way analysis of variance revealed that ability, grade level, problem difficulty, and problem setting each had a very significant effect on problem-solving performance, as shown in Table 5. Although boys scored higher than girls in grade 1, the reverse was true in each of the other two grades and, overall, sex was not a significant factor. Girls performed better than boys in the third and fifth settings, where they seemed better able to handle the color-attribute distraction. The mean scores in Problem A and Problem B were 1.34 and 0.69 respectively. Only a small number of children were able to handle the problem involving a remainder, where the irrelevancies were more distracting than in Problem A. Many subjects tried to partition all 13 cars into three equivalent sets. The mean scores for the high and low ability groups were 1.19 and 0.84 respectively. Only those interaction effects with a significance level below 0.10 are reported in Table 5. Scores on Problem A were much the same for both ability groups, but scores for the low ability group fell sharply in Problem B, whereas the high ability group’s scores fell only slightly. First-graders scored low on both problems. However, performance on Problem A increased sharply in grade 2 and continued to increase in grade 3, while scores on Problem B increased very slowly from grade to grade.

TABLE 4
MEAN SCORES ON BOTH PROBLEMS FOR EACH GRADE IN THE
FIVE PROBLEM SETTINGS

Grade	Problem Setting					
	1	2	3	4	5	1-5
1	0.46	0.83	0.88	0.46	0.08	0.54
2	1.58	1.38	1.46	0.38	0.75	1.11
3	1.79	1.83	1.75	0.63	1.00	1.40
1-3	1.28	1.35	1.36	0.49	0.61	1.02

TABLE 5
SELECTED RESULTS OF FIVE-WAY ANOVA

Source*	df	MS	F Ratio	Probability
A	1	2.844	2.349	0.12672
B	1	37.378	30.862	0.00000
C	1	11.378	9.395	0.00243
D	2	22.858	18.874	0.00000
E	4	13.357	11.029	0.00000
B × C	1	4.900	4.046	0.04541
A × D	2	2.953	2.438	0.08949
B × D	2	5.853	4.836	0.00876
B × C × E	4	2.768	2.286	0.06086
A × B × C × E	4	3.857	3.185	0.01422
Error	240	1.211		

* A = Sex, B = Difficulty, C = Ability, D = Grade, E = Setting

The relationship between conceptual tempo and distractedness is illustrated in Figure 6. The mean scores for reflective and impulsive subjects were 1.42 and 0.61 respectively, with the difference being highly significant ($z = 6.27, p < 0.0002$). The nondistracted reflective group with a mean score of 2.20 was far superior to the distracted impulsive group which had little or no success with a mean scores of 0.21 ($z = 13.49, p < 0.0002$). Reflective subjects were no less distracted than impulsive subjects, but most of those who overcame distractions were in the reflective group. Conceptual tempo was independent of sex, ability, and grade level.

Discussion

The findings indicate that young children are easily distracted by irrelevancies in a problem setting. It appears that distracted children identify and attempt a different problem from the one assigned. In the fourth and fifth settings, with bays marked on the trucks, most children seemed to think they had to find out how many cars would fit on each truck, so they simply counted the bays to solve their problem. In the other three settings children would often count spaces on the trucks or load cars to see how many would fit. Some children who were distracted by color appeared to see the problem as one requiring the matching of cars and trucks according to color. Others thought the required task was to match colors and, at the same time, put the same number of cars on each truck. The remainder involved in Problem B was not considered as a distraction for the purposes of this study, but it seemed to act as such. Many children tried to put all 13 cars on the three trucks and also get the same number on each.

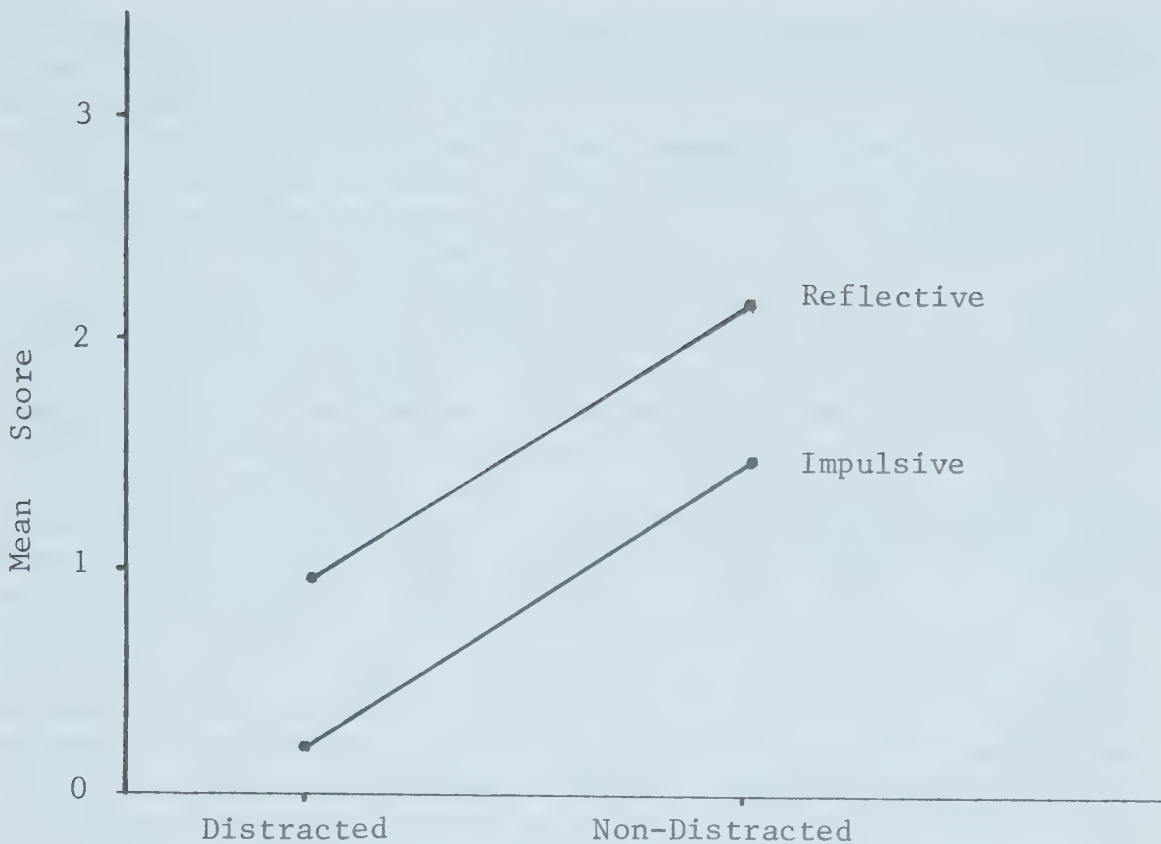


Figure 6. Relationship between distractedness and conceptual tempo.

For the distracted child the relevant information becomes irrelevant. For example, those who were distracted by spatial-numerical cues focused on the amount of room on the trucks and ignored the fact that there were either 12 or 13 cars to distribute. The situational distractions built into the second and fifth problem settings had no effect as such. Some children were distracted by the men on the trucks, but only in a spatial-numerical sense in that they were considered to take up room. Thus, it appears that a distraction only comes into play if it forms the basis for some plausible alternative problem for the child. Six of the subjects reasoned that there would be three cars on each truck because there were three trucks; thus apparently misinterpreting the problem question. It is likely that the verbal problem question will affect distractedness in the problem setting. The performance of subjects on Problem A in the exploratory study (Bana & Nelson, in press) was higher than in the main study and the difference may be due, at least in part, to the fact that the problem question was posed differently in each case. More research is needed to investigate the interaction of irrelevancies in the problem question with those in the problem setting.

Among verbal solvers, girls were less distracted than boys. Also, girls seemed better able to cope with color-attribute distractions. However, more research should be undertaken to establish any sex differences more definitively. With an increase in grade level fewer children were distracted, and those who were seemed better able to overcome the distraction. Developmental differences in problem-solving performance are apparently

related to the ability to cope with noise. This feature may be noted in the acquisition of Piagetian concepts. For example, children who can conserve numerosness have learned to ignore irrelevant perceptual cues such as length or configuration. However, as Suydam (1976) points out, different situations can yield different results on Piagetian tasks. Hence, whether a child is classified as a conserver or nonconserver probably depends on the effect of the irrelevancies in the particular setting.

Different settings can yield different performances. If a child succeeds in one setting teachers should not be deluded into thinking that the task has been mastered. Children should be subjected to the same problem in a variety of situations, along the lines of the multiple embodiment principle proposed by Dienes (1971). More research is needed to investigate the role of all the major types of distractions over a wide variety of problems. Skemp (1971) suggests that situations should be presented with few irrelevancies initially, then the noise level gradually increased. However, longitudinal studies would be needed to verify this. Children need to develop the ability to cut through noise in order to abstract mathematics from the environment. The findings suggest that young children are not given sufficient experience with manipulative materials or with partitive division problems, as indicated by the reluctance of many subjects to manipulate materials and the lack of systematic approaches. Finally, the low success rate of impulsive responders suggests that teachers should not hurry children's responses; rather, they should encourage children to reflect on each problem and thus provide more opportunity to cope with distractions.

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Logico-Mathematical and Spatial Development in Children Underachieving in Arithmetic

The WISC, several Piagetian logico-mathematical and representational space tasks, the Frostig DTVP, and a test of motor ability were administered to elementary school children at three age and three arithmetic achievement levels, to determine whether specific patterns of cognitive and/or spatial development are related to arithmetic achievement, and whether the patterns vary with age.

Verbal intelligence as measured by the WISC emerged as a significant factor and at the three age levels; however, WISC performance IQ did not. WISC Digit Span and Arithmetic, reported in the literature to reflect a factor described as "freedom from distractibility," differentiated achievers from those severely deficient in quantitative thinking ability. Four Piagetian tasks, seriation, inclusion of classes, and length and number conservation, accounted for 71.69% of the variance at the seven-year level. At the nine-year level, WISC Vocabulary and a Piagetian measurement task accounted for 61.16 and 15.19% of the variance respectively. Figure Ground and Form Constancy from the Frostig were significantly related, but only at ages seven and nine. Motor ability was not significantly related. One of the five representational space tasks, the concept of opposition of left and right, was significantly related to arithmetic achievement but only at the eleven-year level, contributing 34.40% of the variance, while WISC verbal IQ contributed 31.26%.

It was concluded that specific patterns of cognitive and spatial-motor development do characterize elementary school children at different achievement levels and the patterns do vary with chronological age. (Dr. Whyte is Professor in the Department of Educational Psychology at The University of Alberta.)

The teaching of mathematics in elementary grades traditionally has consisted in imparting content thought to be suitable for the majority of children at particular grade levels. Recently there has been emphasis on theoretical models of development and learning as the basis for instruction. Both traditional and modern approaches to curriculum development and instruction may be too narrow in scope. Often the child's emotional and cognitive development as well as specific cognitive deficits, factors which

could contribute to difficulty in learning mathematics content, are ignored. Furthermore, the tendency is to treat mathematics content as an entity, with little thought given to prerequisite skills which may vary as content varies.

The present study was designed to determine whether children at three age levels and three achievement levels in elementary school arithmetic differ in skills thought to be prerequisite to acquiring an understanding of the natural number system.

Related Theory and Research

The Nature of Mathematics Content

There is little agreement in the literature concerning the factors which comprise mathematics content. Hyde (1970) and Lovell (1961, 1966) emphasized the importance of perception to the development of number. Vernon (1950) concluded from a review of research that while g-saturation (general intelligence) varies for various forms of arithmetic, there is general agreement in the factorial literature that one of the fundamentals of arithmetic is the general factor described as g.

Piaget's theory of number (1941) postulates a conceptual basis. Number, according to Piaget, is at the same time both class and asymmetrical relation, derives from the union of these logical operations, and is the result of the fusion of several related notions: conservation of continuous and discontinuous quantities; provoked correspondence and equivalence of corresponding sets; spontaneous correspondence and the cardinality value of sets; seriation; the synthesis of cardinality and ordination. These notions grow out of a pre-numerical and pre-logical period, are organized in an invariant sequence of stages, and culminate in a structure Piaget terms conservation, that is, "A set or collection (which) remains unchanged irrespective of the changes occurring in the relationship between the elements" (Piaget, 1941, p. 1).

The few studies attempting to verify that number results from the union of class and asymmetrical relation have not supported the hypothesis, e.g., Dodwell (1962). There is, however, a considerable body of research confirming a relationship between basic number concepts postulated by Piaget and arithmetic achievement, e.g., Dodwell (1961, 1962), Hood (1962), Beard (1963), Brown (1969). While operativity as defined by Piaget and general intelligence as defined by Vernon are both considered aspects of conceptual development, factor analytic findings tend to separate psychometric tasks and Piagetian tasks on different factors (Lunzer, 1971; Kohlberg & DeVries, 1974).

An alternative but controversial hypothesis also advanced is the notion that space is a fundamental factor in arithmetic content. While some researchers consider space an essential factor in arithmetic content, e.g., McFarlane-Smith (1964), others such as Vernon (1950) concluded k (space) and n (number) tests are strongly opposed, apart from g. Recent research in spatial development holds promise for resolving the controversy. Generated largely from the work of Piaget (1960, 1967), the research attempts to define and clarify the nature of spatial development.

Unfortunately, there is no extensive literature on the Piagetian tradition on arithmetic and spatial concepts to review; however, three studies are relevant to the present discussion. Mycock (1969) concluded the SRA Space Test had no high correlations with any of the Piagetian spatial tests but he

reported a spatial factor of a specific kind involving perception of similarities in geometrical figures. Goldschmid and Bentler (1968) administered number conservation tasks, two-dimensional space tasks, and three tasks on conservation of length to children from 5 to 7 years. They concluded the number conservation tests were not measuring exactly the same dimension as the area and length tasks. Conservation of number correlated .52 with arithmetic while length and area correlated .39. Goldschmid (1967) reported conservation of number tests were positively correlated with IQ, MA, and verbal ability. Both two- and three-dimensional space tasks correlated significantly with conservation tasks, although the range of correlations for the latter was much lower (.16 to .26) than for the former (.31 to .61). The correlations with total conservation were .66 and .35 for two- and three-dimensional space tasks respectively and .54 and .17 between number and two- and three-dimensional space tasks respectively. It would appear that two- and three-dimensional space tasks are fairly heterogeneous abilities.

The lack of consensus among researchers concerning the relationship of space and arithmetic is due in part to the failure of researchers to agree on what is meant by space. Dodwell (1971) stated the problem, "there is a valid distinction to be drawn between the apprehension, or discrimination, of forms and objects, and the understanding of their nature—or the conception of space and spatial relations. The weaknesses in modern perceptual theory come about largely through failure to observe this distinction" (p. 119).

Piaget (1967) does make the distinction, that is, a distinction between a perceptual space and a cognitive space. Cognitive space is operative and operational knowledge is dependent upon intelligence at all levels. Perceptual space is figurative and is dependent upon perception. Cognitive space becomes representational when the symbolic function appears around two years of age and, unlike perceptual space, develops in sequential stages.

These notions of space may have potential value for understanding the literature relative to space and arithmetic, particularly as it relates to learning disabilities. Research in learning disabilities appears to be concerned with perceptual space and arithmetic disability, emphasizing disabilities in motor development and visual perception as they relate to failure in learning arithmetic, e.g., Ayres (1965, 1975). The tendency for spatial disabilities and arithmetic disability to occur together is well documented in the literature. Not so well documented is the nature of the relationship.

Causes of Arithmetic Disability

The etiology of arithmetic disability seems as varied as the factors which constitute arithmetic content. Lowered intellectual capacity is one cause of diminished ability to learn arithmetic but many intellectually capable children seem unable to acquire an understanding of number systems.

Although findings vary with grade and/or C.A. level, Hood (1962), Almy (1966), Goldschmid (1968), Reimer (1968), Wheatley (1970) and Riggs (1970) in general reported significant correlations between arithmetic achievement and ability to conserve. Results are not as positive when older children are assessed; for example Overholt (1964) found no significant differences in arithmetic achievement between fourth-grade conservers and nonconservers

when he controlled for IQ. While nonconservation in number concepts appears an etiological factor in arithmetic disability, at least in kindergarten and grade one, there is insufficient evidence concerning stage of development in classification tasks, largely because the research has not been done.

Spatial deficit is also postulated as an etiological factor in arithmetic disability. Blackall (1972) studied conservation, perceptual efficiency and estimation of length, area and numerical quantity in grade three children performing at three achievement levels in arithmetic. The three groups differed significantly in visual and auditory discrimination, memory and closure (all said to have a spatial theme and probably measures of perceptual space). Four of the five factors reported are relevant; Factor I contained arithmetic, intelligence, reading, visual discrimination and auditory memory and closure. Factor II was a conservation factor, Factor III was tactual in nature, while Factor IV was a representation factor, including tasks requiring drawings of shapes presented visually and tactually. It would appear from this study that both perceptual and representational space as well as conservation and general intelligence play a role in the degree of arithmetic achievement attained by grade III children.

There is a particularly severe form of arithmetic disability termed *acalculia* or *dyscalculia*, generally defined as a disturbance or impairment in the ability to do simple arithmetic, usually associated with neurological dysfunction or brain damage, and which interferes with quantitative thinking. The characteristics most often cited are deficiency in visual-spatial organization and nonverbal integration manifested by disturbance in ability to distinguish shapes, sizes, etc; disturbances in body image; apraxia; confusion of spatial relationships such as up-down, front-back; clumsiness in manual, postural and ambulatory operations (Johnson & Myklebust, 1967; Kaliski, 1961; Cohn, 1968). Arithmetic errors include malformed or large number symbols, inability to recognize operator signs or linear separators, and inappropriate ordering of numbers in multiplication.

Koppitz (1971), in a five-year longitudinal study, reported that children who had to be hospitalized manifested the lowest arithmetic achievement and the most extreme, aggressive, explosive and delinquent behaviour which she attributed to their exceptionally poor integration as measured by the Bender Gestalt Test. Research has shown a close correlation between performance on the Bender and arithmetic achievement, and both are related to children's integrative ability and their overall behaviour.

Finger agnosia, agraphia and left-right confusion, alone or in combination, are frequently found among children with dyscalculia. Werner and Carrison (1963) concluded that finger agnosia, a failure to recognize, show, and name the fingers of either hand, may be associated with a tactile dysfunction, a deficit in visual form and perception, or a disturbance in language function. Benton (1959) reported finger agnosia and right-left disorientation tend to occur together with the highest correlations (.62) between left-right orientation and finger localization, and calculation.

A developmental variant of constructional apraxia described by Ayres (1975) as a disturbance in motor planning and by Grewel (1951) as a disturbance of spatial handling, has been reported by Kinsbourne and Warrington (1963) and Ayres (1965). In the former study, subjects were best

represented by a marked specific disability in certain "spatial tasks," low WISC performance IQ and marked discrepancy between the subtest pairs of Block Design and Object Assembly, and Vocabulary and Digit Span, while Ayres reported the factor loading significantly on every test of tactile perception and apparently related to eye-pursuit and two aspects of body scheme: tactile impulses and integration of both sides of the body. Ayres also reported a substantial relationship between skill in number concepts and perceptual-motor functions.

Finally, Sabatino and Hayden (1970) in a study of 472 children failing elementary grades reported that many of the perceptual tasks were correlated significantly with WRAT arithmetic achievement scores for children less than C.A. 9-6 but there were considerably fewer significant correlations for children older than 9-6. They concluded that basic perceptual behaviours are not directly related to academic achievement for older children.

In summary, it is hypothesized that two etiologies of arithmetic disability are associated with cognitive and spatial disability. While low intellectual capacity is one cause, a major etiology appears to be associated with lack of operational level thought in logico-mathematical concepts. A second major etiology appears to be associated with a complex syndrome of spatial-motor disability. Motor and perceptual deficits which in turn may be caused by disorders in such systems as tactile, appear to be related to, or perhaps even form the basis of the problem. It is not clear whether the spatial problem is perceptual or conceptual in nature (or a complex combination of the two) but the greatest number of studies seem to have been concerned with perceptual space. The factor of age also complicates the problem, since prerequisite skills for arithmetic learning at younger ages do not appear to be the same for older children.

The Study

It was hypothesized that two major causes of arithmetic disability are related to dysfunction(s) in cognitive and spatial-motor development. The present study compared the performance of elementary school children at three age levels and three achievement levels in arithmetic, on logico-mathematical and spatial development tasks.

Subjects

Nine groups of children (N = 87) at three C.A. levels (7, 9 and 11 years) and performing at three levels in arithmetic achievement (achievers, underachievers, and nonachievers) were included. Achievers were defined as children achieving from 75 to 100% of grade level expectation on a diagnostic arithmetic test covering content from grades I to VI, while underachievers and nonachievers achieved from 50 to 74% and less than 50%, respectively.

Achievers and underachievers were selected from a large elementary school in Edmonton, which drew its population from low, middle and high SES families. Nonachievers at ages nine and eleven were selected from adaptation classes designed for children with learning disabilities, while seven-year-old nonachievers were referred by school psychologists from two elementary schools. C.A. and IQ descriptions are presented in Table 1.

TABLE 1
C.A. and IQ DESCRIPTION OF SUBJECTS

Group	N	C.A.			IQ								
		$\bar{X}$	SD	Range	WISC VERBAL			WISC PERFORMANCE			WISC FULL SCALE		
					$\bar{X}$	SD	Range	$\bar{X}$	SD	Range	$\bar{X}$	SD	Range
VII A	9	89	3.00	84-93	124.1	18.89	103-153	115.9	11.45	93-135	122.1	14.39	99-145
VII U	9	90.11	3.95	85-95	98.8	9.54	84-113	109.7	13.91	81-132	104.3	6.14	90-109
VII N	10	91.90	5.24	84-97	94.5	12.89	75-116	97.7	15.28	65-118	95.7	12.36	67-119
IX A	10	113.60	2.27	110-117	116.6	12.08	97-135	112.0	17.76	86-145	116.1	14.26	99-144
IX U	10	118.40	5.44	112-130	106.2	11.36	87-123	104.4	17.40	89-149	105.9	12.41	88-138
IX N	9	112.44	4.72	105-119	89.3	10.26	75-104	92.2	8.36	79-100	89.7	7.17	79-99
XI A	10	138.10	4.04	132-143	102.1	8.28	91-113	103.2	14.73	83-125	104.0	10.63	90-119
XI U	10	138.30	2.58	135-143	97.5	10.35	85-115	103.8	11.77	86-125	100.5	6.14	90-109
XI N	10	145.10	11.88	127-164	79.5	11.46	62-96	91.0	16.85	58-111	83.8	11.78	62-98

Procedure

Tests Administered. The diagnostic arithmetic test was administered individually to each subject to determine achievement level and each was then administered a battery of tests. Three types of tests were administered: tests of cognitive development, spatial development and the diagnostic arithmetic test.

The WISC was administered to assess intelligence but performance on the subtests was also examined to determine whether specific patterns were associated with achievement and/or C.A. level.

Three types of Piagetian logical thinking tests were administered:

1. Inclusion and multiplication of classes, both classification tests;
2. A number conservation and a seriation test to assess number concepts;
3. Conservation and measurement of length, tests of infralogical development.

Three areas of spatial-motor development were assessed:

1. Visual perception: the five subtests of the Frostig Developmental Test of Visual Perception (1966) were administered, Eye-motor Coordination, Figure Ground, Form Constancy, Position in Space and Spatial Relations.
2. Motor development was assessed with the Oseretzky Test of Motor Development (Stott, 2nd revision, 1966). Five areas of motor ability are included: balance of the whole body, control of the upper body, locomotor control, manual dexterity, speed and precision and a total motor disability score.
3. Five Piagetian tests of representational space described by Laurendeau and Pinard (1970) were administered: (a) Stereognostic recognition of shapes, (b) Construction of a projective straight line, (c) Localization of topographical positions, and (d) Coordination of perspectives.

The diagnostic arithmetic test was designed for the study by the author with the assistance of Dr. Kenneth Lovell, University of Leeds, and included four subtests: counting concepts, place value concepts, properties or laws of

the natural number system and computational skills. Content was a representative sampling of the arithmetic curriculum from grades I to VI. The test was administered to subjects individually, scores for each section were qualified for each grade level, a total score from the combined subtests was computed, and the subjects were categorized as achievers, underachievers, or nonachievers by the total score earned.

Analysis of Data

1. Means for the nine groups for each of 35 variables were computed and the Tukey Gap Value Statistic (Tukey, 1949) applied to detect significant differences between the means at $p = .01$ level.
2. A Multiple Stepwise Regression Analysis was computed for the three chronological age levels to determine which variables were contributing the greatest percentages of variance for the variable, Total Arithmetic Score.

Questions Investigated

Four questions were investigated:

1. Will elementary school children classified as achievers, underachievers, and nonachievers in arithmetic be characterized by specific patterns of development on the WISC, tests of logico-mathematical concepts, and/or tests of spatial development?
2. If specific patterns of development do characterize children at the three achievement levels, will the patterns also vary across the variable, chronological age?
3. Are one or more measures of spatial development related to arithmetic achievement?
4. Which of the four areas of the natural number system assessed are most seriously deficient at each of the three chronological age levels?

Results

Cognitive Development

A. WISC:

Group means for verbal and performance IQs have been presented in Table 1. WISC comparisons significant at $p = .01$ level are presented in Table 2. For brevity in reporting results, Roman numerals VII, IX, and XI are used to indicate age levels and combined with abbreviations A, U and N for achievers, underachievers, and nonachievers respectively to indicate achievement levels.

The seven achievers (VII A) were an intellectually superior group and significant differences were found for verbal IQ between VII A and every group except IX A. In performance IQ, however, VII A differed significantly with only two groups, IX N and XI N. For verbal IQ there appeared to be a pattern. Both achievers and underachievers differed significantly from nonachievers. In only one case (VII A and VII U) did achievers differ significantly from underachievers. The pattern was not repeated for performance IQ, where only one significant comparison was found, between IX A and IX N. All other significant comparisons were across age groups.

TABLE 2
DIFFERENCES IN WISC MEAN SCORES

Group	WISC Variable	Tukey Gap Values							
		VII U.	VII N	IX A	IX U	IX N	XI A	XI U	XI N
VII A	Verbal IQ ^a	25.3	29.6		17.9	24.5	22.0	26.6	44.6
	Performance IQ ^b					23.9			24.9
	Information ^c	4.6	4.8			5.2	3.6	4.3	7.1
	Arithmetic ^d	3.9	4.6		3.8	6.2		4.4	5.4
	Vocabulary ^e	3.7	4.5			5.0	3.7	3.9	7.7
	Digit Span ^f	4.2	3.3		3.3	5.3		3.8	4.9
	Coding ^g					3.7			4.5
VII U	Verbal IQ			17.8					19.3
	Performance IQ								18.7
	Vocabulary			2.9					4.1
	Digit Span						3.1		
	Coding								3.97
VII N	Verbal IQ			22.1					
	Arithmetic			3.9					
	Vocabulary			3.8					3.2
	Coding			3.9					
IX A	Verbal IQ					27.0		19.1	37.1
	Performance IQ					19.8			21.0
	Information					3.2			5.1
	Arithmetic					5.5		3.7	4.7
	Vocabulary					5.3	3.0	3.2	7.0
	Digit Span					3.0			2.6
	Coding					5.8		4.0	6.7
IX U	Verbal IQ					16.6			26.7
	Information								4.3
	Vocabulary					3.1			5.8
	Digit Span						4.2		
	Coding								3.8
XI A	Verbal IQ								22.6
	Information								3.5
	Vocabulary								4.0
	Digit Span							2.7	3.8
XI U	Verbal IQ								18.0
	Vocabulary								3.8

Tukey Gap Values significant at .01 level: ^a15.17; ^b18.50; ^c3.208; ^d3.723; ^e2.947; ^f2.640; ^g3.547.

There were no significant comparisons for the Picture Completion subtest and only three, two, and one for Picture Arrangement, Block Design, and Object Assembly respectively. Significant comparisons for the remaining subtests are reported in Table 2. Vocabulary was the subtest most often involved in the comparisons found to be significant, with 18 of 36 possible comparisons being significant, followed by Digit Span with 12 and Arithmetic and Information each with eight. Except at the seven-year level where VII A differed from both VII U and VII N, the largest number of significant comparisons within age levels were between achievers and nonachievers with very few significant comparisons between achievers and underachievers or underachievers and nonachievers. The remain significant comparisons were across age levels.

B. Logico-Mathematical Tests:

The mean stage of development for each of the Piagetian tests is reported in Table 3, while comparisons which were significant are reported in Table 4. To analyze the data, the stages and substages were converted to a numerical scale from 1 to 7 as follows:

Stage	Period of Development	New Scale
0	No response, presumably sensorimotor	1
1A		2
1B		3
2A	Preoperational Period	4
2B		5
3A		6
3B	Concrete Operational Period	7

Classification Tests. Three groups of achievers were functioning at the concrete operational stage in inclusion of classes, while underachievers and nonachievers with one exception (IX U) were preoperational. The nine- and eleven-year achievers and underachievers were operational in multiplication of classes. While differences at each age level were slight, there was a tendency for nonachievers to be less advanced than the two other groups.

Number Concepts' Tests. Except for groups VII A and VII N, most subjects were operational in number conservation. Only two groups, VII A and IX A, were functioning at the expected stage on the seriation task. Normal children tend to become operational on this task at approximately nine years. Several children in group XI A in the low normal range of intelligence on the WISC were preoperational on the seriation task.

Infralogical Tests. Most children were concrete operational on the

TABLE 3
STAGE OF DEVELOPMENT ON LOGICO-MATHEMATICAL AND
REPRESENTATIONAL SPACE TASKS

Test	Stage of Development								
	VII A	VII U	VII N	IX A	IX U	IX N	XI A	XI U	XI N
<u>Classification Tests</u>									
Inclusion of Classes	7.0	3.89	4.20	6.80	6.80	5.89	6.25	5.40	5.40
Multiplication of Classes	5.89	4.33	4.45	6.60	6.00	5.28	6.45	6.60	5.60
<u>Number Concept Tests</u>									
Conservation of Number	7.0	5.44	5.05	7.0	7.0	6.39	7.0	7.0	7.0
Seriation	5.22	3.56	3.20	6.20	4.45	4.44	5.70	5.40	4.60
<u>Infralogical Tests</u>									
Conservation of Length	6.56	5.89	6.20	7.0	7.0	6.33	7.0	7.0	6.80
Measurement	4.17	2.61	2.60	6.40	5.60	3.44	7.0	6.80	5.20
<u>Representational Space Tests</u>									
Stereognostic Recognition of Shapes	6.33	6.22	6.20	6.70	6.50	6.00	6.70	6.50	6.00
Construction of a Projective Straight Line	5.00	5.22	5.20	6.70	6.60	5.56	6.90	6.10	5.90
Localization of Topographical Positions	6.67	6.11	6.10	6.70	6.10	5.00	6.30	6.40	6.10
Concept of Opposition of Left and Right	5.00	3.00	3.70	4.20	3.70	3.78	5.60	4.80	3.80
Coordination of Perspectives	3.67	3.11	3.20	5.00	4.80	4.11	4.80	5.20	4.60

TABLE 4
DIFFERENCES IN LOGICO-MATHEMATICAL AND REPRESENTATIONAL
SPACE TEST MEAN SCORES

Group	Test	Tukey Gap Values							
		VII U	VII N	IX A	IX U	IX N	XI A	XI U	XI N
VII A	Inclusion ^a	3.12	2.80					1.60	1.60
	Multiplication ^b	1.60							
	Number ^c	2.56	1.95						
	Seriation ^d		2.02						
	Measurement ^f			2.24			2.84	2.64	
	Straight Line ^g			1.70	1.60		1.90		
	Topographical Positions ^h					1.66			
	Concepts of Left & Right ⁱ	2.00							
VII U	Inclusion			2.92	2.92	2.00	2.32	1.58	1.58
	Multiplication			2.27	2.27		2.12	2.27	
	Number			1.56	1.56		1.56	1.56	1.56
	Seriation			2.65			2.10	1.85	
	Length ^e			1.12	1.12		1.12	1.12	
	Measurement			3.79	2.99		4.39	4.19	2.59
	Straight Line			1.48			1.60		
	Concepts of Left & Right						2.60		
VII N	Inclusion			2.60	2.60	1.68	2.00		
	Multiplication			2.15	2.15		2.00	2.15	
	Number			1.95	1.95	1.33	1.95	1.95	1.95
	Seriation			3.00			2.45	2.20	
	Measurement			3.80	3.00		4.20	4.20	2.60
	Straight Line			1.50			1.70		
	Coordination of							2.00	
	Perspectives ^j								
IX A	Seriation				1.76	1.76			
	Measurement					2.56			
	Topographical Positions					1.70			
IX U	Measurement					2.16			
IX N	Measurement						3.56	3.36	
	Topographical Positions						1.30	1.40	
XI A	Measurement								1.80

Tukey Gap Values significant at .01 level: ^a1.588; ^b1.588; ^c1.61; ^d1.761; ^e1.039; ^f1.792; ^g1.484; ^h1.133; ⁱ1.944; ^j1.825.

conservation of length task and the majority of children in groups IX A, XI A and XI U were also operational on the measurement task.

In most instances the trend was increased average stage of development as C.A. increased, e.g., for nonachievers mean stages on the measurement task were 2.60, 3.44 and 5.20 for seven-, nine-, and eleven-year-olds respectively. At each age level average stage was lower as achievement level decreased, e.g., in measurement the mean stages for seven-, nine-, and eleven-year-olds respectively were 4.17, 6.40, 7.0 for achievers, 2.61, 5.60 and 6.80 for underachievers and 2.60, 3.44 and 5.20 for nonachievers. While there were differences, they were not always significant and the majority were between age levels as might be expected (Table 4). At the seven-year level the

differences were between achievers, and underachievers and nonachievers, but not between underachievers and nonachievers. Except for measurement the same trend was found at nine years, while at eleven years one significant comparison was found (XI A and XI N).

The number of tasks where comparisons were significant decreased as C.A. increased, that is, significant comparisons were found for six, two, and one tasks for seven-, nine-, and eleven-year-olds respectively. While logico-mathematical concepts appear to be prerequisite for learning arithmetic, development of operational thought at older ages may not result in academic achievement. Possibly other complicating factors such as motivation are involved, or it may be that operational thought, while essential, is not sufficient for learning arithmetic.

Spatial-Motor Development

A. Frostig Developmental Test of Visual Perception:

No significant comparisons were found for the Eye-Motor Coordination and Spatial Relations subtests. Fourteen comparisons were significant, but only four were within age levels and three involved Form Constancy. Group VII A differed from VII N on Figure Ground and Form Constancy (Tukey Gap Values 15.6 and 23.8 respectively). Groups IX A and IX U differed significantly from IX N on Form Constancy (Tukey Gap Values 22.8 and 24.6). The remaining significant comparisons were across age levels.

B. Oseretzky Test of Motor Ability:

Except for manual dexterity, speed and precision and total motor error score, performance on this test was almost error free. Two comparisons were significant for the manual dexterity subtest, groups VII U and XI N, and IX and XI N. Two comparisons involving the speed and precision subtest were significant between groups VII A and XI N, and XIA and XI N. Four comparisons for total motor score were significant, group VII A, VII U, IX A and IX U, when compared with XI N. There was a tendency at each age level for the average error score to increase as the degree of arithmetic disability increased.

C. Representational Space Tests:

Mean stages on the five space tasks are reported in Table 3, while comparisons which were significant are reported in Table 4. All subjects were operational on the stereognostic recognition of shapes test. Subjects at the seven-year level and groups IX N and XI N were preoperational on the task, construction of a projective straight line. Seven comparisons for the task were significant but all were across age levels. One group, IX N at stage 2B, was preoperational on the localization of topographical positions test but four comparisons involving the task were significant; however, only one comparison (between IX A and XI N) was within an age level.

No group was operational on either the concept of opposition of left and right test or the coordination of perspectives test; however, Laurendeau and Pinard (1970) reported that normal children range from C.A. ten to twelve before operational thought appears for the former task, while stage 3 generally is not initiated for the latter task before 13 years. For the former task average stages at the seven-year level were consistent with norms (Laurendeau & Pinard, 1970) but at nine years, groups were slightly below

expected stages. At eleven years most subjects should be operational but only group XI A subjects were. Subjects were functioning at or slightly above expected levels on the coordination of perspectives test. Differences between groups were minimal. The concepts of left and right test differentiated seven-year achievers and underachievers, while nine-year achievers and nonachievers differed significantly on the localization of topographical positions test. All other significant comparisons were across age levels.

Arithmetic Achievement

Although subjects were categorized by total score from the combined arithmetic subtests, performance on each subtest was analyzed separately. Means are presented in table form (Table 5). For brevity, significant comparisons are not reported in table form but are available from the author.

TABLE 5
AVERAGE SCORES ON DIAGNOSTIC ARITHMETIC TESTS

Group	Average Arithmetic Scores				Total Score
	Counting	Place Value	Properties	Computational Skills	
VII A	15.00	20.56	6.11	5.67	47.33
VII U	12.33	10.89	3.56	1.56	28.33
VII N	9.70	3.20	3.10	1.80	17.60
IX A	23.00	22.50	10.30	32.10	87.90
IX U	20.40	22.50	8.30	21.20	72.60
IX N	13.22	9.22	2.33	9.22	34.00
XI A	25.20	24.70	14.30	44.70	108.90
XI U	23.00	23.90	11.40	33.90	92.20
XI N	16.30	15.50	2.90	16.40	51.10

All groups different significantly on total arithmetic score, both within and across age levels. At the seven-year level achievers differed significantly from underachievers in place value concepts, while achievers and underachievers at nine and eleven years also differed significantly in one area, computational skills. Achievers differed significantly from nonachievers in every area. At seven years underachievers differed from nonachievers in one area, place value, while IX U and IX N, and XI U and XI N differed significantly in every area. Other significant comparisons were across age levels.

Multiple Stepwise Regression Analysis

A multiple stepwise regression analysis was computed for each age level for the variable, total arithmetic score. Results are reported in Table 6.

At the seven-year level, seriation accounted for 52.75% of the variance, while inclusion of classes accounted for an additional 12.64%. Both tasks require conservation ability and operational thought. Three other Piagetian tasks, conservation of length, number conservation and concepts of left and right, accounted for 8.90% for a total of 74.31% of the variance. WISC

TABLE 6
MULTIPLE STEPWISE REGRESSION ANALYSIS

C.A. Group	Variable	Percent of Variance	Cumulative Variance
VII Years	Seriation	52.75	52.75
	Inclusion of Classes	12.64	65.39
	Total Motor Score	3.50	68.89
	WISC: Information	3.49	72.38
	Length Conservation	3.24	75.62
	WISC: Object Assembly	3.21	78.83
	Number Conservation	3.06	81.89
	Concepts of Left and Right	2.62	84.51
IX Years	WISC: Vocabulary	61.16	61.16
	Measurement of Length	15.19	76.35
	WISC: Digit Span	3.57	73.92
	WISC: Coding	3.38	83.30
	DTVP: Position in Span	3.33	86.63
	WISC: Block Design	1.86	88.49
XI Years	Concepts of Left and Right	34.40	34.40
	WISC: Verbal IQ	31.26	65.66
	WISC: Digit Span	6.32	71.98
	WISC: Arithmetic	5.83	77.81
	DTVP: Figure Ground	2.77	80.58
	Oseretzky: Speed and Precision	2.76	83.34
	DTVP: Position in Space	1.51	84.85

Information and Object Assembly, DTVP Spatial Relations, and total motor score accounted for 12.41% for a cumulative percentage of 86.85%.

At the nine-year level WISC Vocabulary accounted for 61.16% of the variance and measurement, a Piagetian task, for 15.19%; that is, two tasks accounted for 76.35% of the variance. WISC Digit Span, Coding and Block Design and DTVP Position in Space increased the cumulative percentage to 88.49%.

At the eleven-year level concept of opposition of left and right, a Piagetian task, and WISC verbal IQ accounted for 34.40 and 31.26% of the variance respectively. WISC Digit Span and Arithmetic accounted for 12.15%, speed and precision for 2.76% and DTVP Figure Ground and Position in Space for 4.28% for a total cumulative percentage of 84.85%.

Conclusions

It would appear that verbal intelligence as measured by psychometric tests is an essential factor in acquiring an understanding of arithmetic and the requirement holds across the age range from seven to eleven years. Achievers emerged as children functioning at least in the average range on all tasks administered. There was marked superiority in verbal skills and average ability in nonverbal skills. Most accelerated were WISC verbal IQ, Vocabulary and Information, all “good” measures of general intelligence (Cohen, 1959). Ability in verbal intelligence tended to separate both achievers and underachievers from nonachievers. The finding is consistent with conclusions by Koppitz (1971).

Logico-mathematical concepts, as measured by Piagetian tasks, appeared

to play an essential role in learning arithmetic but mainly at seven years and to a lesser extent, at nine years. Operational thought in seriation emerged as the most important ability at seven years, followed by inclusion of classes and length and number conservation. Seriation and/or measurement were also involved to a significant degree at nine and eleven years. The pattern appears to be one of slow development towards operational thought, but continuing arithmetic disability. In the early years, operational thought in logico-mathematical concepts appears to be essential for initial success.

Bannatyne (1968) described a spatial organization pattern which includes scores from WISC Picture Completion, Block Design and Object Assembly. The subtests, both alone and in combination, did not differentiate between arithmetic achievement levels in the present study. Bannatyne (1968) also described a sequencing pattern which included WISC Digit Span, Coding and Picture Arrangement subtests. Neither Coding nor Picture Arrangement emerged as significant in the present study; however, WISC Digit Span and Arithmetic emerged as significant both individually and in combination. According to Cohen (1959), at age 13½ Digit Span and Arithmetic combine to measure a factor reflecting "freedom from distractibility." Both subtests differentiated between achievers and nonachievers at seven and nine years, while Digit Span also differentiated between the two levels at age eleven. At eleven years Digit Span and Arithmetic ranked third and fourth respectively in percent of variance contributed in the multiple stepwise regression analysis.

Koppitz (1971) reported a high incidence of hyperactive-distractible behaviour among arithmetic disabled children. The most frequent comment made by teachers in the present study concerned the prevalence of hyperactivity, particularly among the nonachievers. Although Cohen (1959) reported the factor for older children, the factor may be appearing as early as seven years for disabled children.

Two areas of visual perception, Figure Ground and Form Constancy, emerged as significant but only at seven and nine years. The finding is consistent with conclusions by Sabatino and Hayden (1970) concerning the shift in emphasis away from perceptual strategies after nine years.

Although the average number of "motor errors" increased as the degree of arithmetic disability increased, differences were not significant; however, total motor score ranked third in the multiple stepwise regression analysis for the seven-year-olds, after seriation and inclusion of classes. Ayres (1965) reported definite ties between number concepts and space relations, form perception, eye-motor skills and body visualization, with particular identification with perceptual deficits of the two sides of the body. While form perception was related to arithmetic achievement at ages seven and nine in the present study, Eye-Motor Coordination on the DTVP and motor ability were not related. The Oseretzky Test of Motor Ability does not appear, however, to assess many of the areas of motor development described by Ayres. From casual observation many children were exhibiting disabilities described by Ayres. A more relevant test might have been the Purdue Perceptual Motor Survey (1970); however, this test is not standardized.

Only one representational space task emerged as significant. At eleven years concept of opposition of left and right ranked first in percent of variance contributed. The test is concerned with the notion of opposition of left and

right on one's own body, the body of a person opposite and the conceptual notion that left and right are not absolutes.

Four questions were investigated in the present study. Questions 1 and 2 can be answered affirmatively. Elementary school children classified as achievers, underachievers and nonachievers were characterized by different patterns of development. Achievers functioned at least in the average range in all areas assessed. Underachievers differed from achievers on verbal tasks and in stage of development on logico-mathematical tasks. Nonachievers differed from achievers in almost every area assessed but the greatest differences were found for verbal skills, logico-mathematical concepts, visual perception skills in Form Constancy and Figure Ground, and concepts of left and right. Nonachievers also differed from underachievers in verbal skills but were similar in most other areas.

The largest number of statistically significant differences were found at the seven- and nine-year levels. Children at the eleven-year level tended to be operational in spatial and logico-mathematical concepts but continued to have difficulties in learning arithmetic. Verbal intelligence as measured by the WISC seemed to become more closely related to arithmetic achievement as chronological age increased, possibly because changing arithmetic content places greater demands on verbal intelligence, or children may shift from perceptual to conceptual problem-solving strategies as they grow older.

Question 3 (Are one or more of the measures of spatial development related to arithmetic achievement?) can also be answered affirmatively. Perception of form and figure ground were related but at ages seven and nine only. One aspect of representational space, concept of opposition of left and right, was related but at age eleven only. Motor ability as assessed in this study was not related, except in one instance; total motor score ranked third in percent of variance contributed at the seven-year level.

Prior to seven or eight years, according to Piaget, children are under the strong influence of perceptual information, even to the point of making false judgments when data seem conflicting. At approximately seven to eight years, children go beyond the realms of perception and make true judgments in spite of confusing perceptual information. According to Sabatino and Hayden (1970), children move away from perceptual problem-solving strategies to conceptual problem-solving strategies sometime after age nine.

In the present study visual perception, and to a lesser extent, motor ability were related to arithmetic achievement at ages seven and nine but in specific areas, perception of form and discrimination of figure ground. One might postulate tentatively that the two are aspects of perceptual space.

Representational or cognitive space apparently was either intact or not prerequisite for arithmetic achievement. Only at age eleven did representational space appear as a significant factor, in understanding the concept of opposition of left and right. At this point, understanding of left and right becomes a complex conceptual notion, that is, operational functioning on this task involves understanding that left and right are relative rather than absolute concepts, since an object can be left or right at the same time depending upon the number and position of elements in the group.

Spatial organization as measured by the WISC was not related to

arithmetic achievement. Presumably, spatial organization as involved in these tasks is primarily a cognitive skill.

A tentative hypothesis is that arithmetic does involve a spatial component, but until age nine the spatial factors involved are specific aspects of perceptual space. Cognitive space does not appear to be related to arithmetic achievement or content in the early years.

Question 4 asked, "Which of the four areas of the natural number system studied are most severely affected at each of the three chronological age levels?" Underachievers at the seven-year level had most difficulty with place value, while nine- and eleven-year-old underachievers had greatest difficulty with computational skills. Nonachievers had more difficulty than both achievers and underachievers in every area assessed, and the differences were statistically significant.

In summary, the psychoeducational approach to educating exceptional children has been criticized most severely for the naive manner in which assessment and programming have been carried out. The criticisms are relevant in many instances. Matching teaching programs and areas of deficit may be overly simplistic until more is known of the demands made by varied academic content at different age and ability levels.

The present study was concerned with the nature of logico-mathematical and spatial deficits manifested by children in various age ranges and levels of competency in arithmetic achievement. The study was limited by the number of children included in each of the nine groups. This limitation should be rectified by additional research with sufficient numbers of subjects to allow for factor analysis of the areas which appear to be related to arithmetic achievement. Only when we have more exact information concerning manifestations of arithmetic disability and more complete data on the demands placed on intellectual functioning by various forms of academic content will we be in a position to truly evaluate the effectiveness of prescriptive teaching.

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Teaching Superordinate Concepts with Simulation Games

The effectiveness of simulation games as a method for teaching superordinate concepts was examined in this study. The simulation involved instruction in map skills and was structured in keeping with Case's (1975) discussion of how to integrate developmental and hierarchical aspects of learning in instructional design. One hundred and eighty-three fifth- and sixth-grade students participated in the week-long experiment. The simulation group demonstrated superior performance on map skills and concepts on the delayed posttest, but not the immediate posttest. Members of this group also showed significant improvement in performance from posttest to delayed posttest. Results were interpreted as supporting the hypothesis that simulations can be a useful way of presenting superordinate concepts so as to facilitate learning of lower level skills. Results also appear to corroborate Case's analysis of effective instructional designs. (Dr. Cohen is Coordinator of Laboratory Experiences and Assistant Professor in the Department of Elementary and Early Childhood Education, and Dr. Bradley is Associate Professor of Educational Foundations and Research Associate at the Center for Child Development and Education, at the University of Arkansas at Little Rock.)

One of the most significant contributions to the analysis of the learning task has been the development of theories about the hierarchical structure of knowledge (Ausubel, 1963; Gagne, 1970; Taba, 1967; and Bloom, 1956). Conceiving knowledge as hierarchical has enabled educators to analyze tasks according to level of learning and to prescribe a sequence of educational activities which provides the necessary prerequisites for acquiring information at any given level.

Several theorists have argued that when individuals know a superordinate concept, it is easier for them to learn subordinate concepts and facts. Ausubel (1963) advocates the use of advance organizers presented at a higher level of abstraction as a means of facilitating learning at lower levels. However,

advance organizers apparently do not always provide the kind of subsumer that facilitates the learning of subconcepts and specific facts (Barnes & Clawson, 1975). This outcome may partially reflect a limited consideration of the developmental aspects of learning in Ausubel's theory. Case (1975) contends that most learning hierarchies do not provide an adequate analysis of learning tasks, particularly for children. He presents evidence that any analysis of a learning task must take into consideration that young children are more likely than adults to respond intuitively in problem-solving situations. They rely on innate response tendencies which prevent them from adequately evaluating phenomena. To accomplish certain tasks children must learn to respond logically rather than intuitively. Case (1975) feels that to be successful, instruction for young children should deal directly with

both the correct response and the incorrect response. . . . In terms of a hierarchical learning theory such as Gagne's, one would say that the child who participates in the successful training acquires a superordinate skill (or "concept," "plan," or "structure") for attacking the problem which allows him to integrate and discriminate two competing lower-order procedures for attacking it. After training he can succeed consistently, not merely because the correct response has been strengthened, but because response competition has been eliminated. Similarly he can transfer what he has learned, but because any new situation that elicits the incorrect response will also elicit the superordinate or mediating structure into which it has become embedded. Finally, he can retain what he has learned, since he has ample opportunity to apply it (at the supper table, for example, or at play) and little opportunity to confuse it with any other response. (p. 74)

Instructional strategies which consider the developmental nature of learning and which are aimed at teaching superordinate concepts offer a potentially useful way to facilitate the learning of subordinate concepts and facts. One method which can provide a framework for acquiring numerous subskills is simulation games. Simulation games may be defined as an activity in which participants who are attempting to achieve specific goals interact within an artificially produced environment which recreates some aspect of social reality. For the purpose of reality, players assume the roles of individuals or groups who exist in the particular social system being simulated. Bruner has argued that simulation games with their emphasis on participation, informed guessing, hypothesis making and conjectural procedures "go a long way toward getting children involved in understanding language, social organization, and the rest; they also introduce . . . the idea of a theory of these phenomena" (Bruner, 1966, p. 92).

Previous research has demonstrated that simulation games are effective in teaching factual knowledge and concepts. However, Coleman, Livingston, Fennessey, Edwards, and Kidder (1973) explain that simulations tend to be weak in that many participants do not generalize from the particular experiences provided in the game to a general principle applicable in other circumstances. They concluded that learning in school might be made considerably more effective by the "appropriate mix of experiential and information-processing modes of learning" (p. 6). Therefore simulations that incorporate both the symbols helpful for generalization and the actions useful for application to particulars may be the most effective.

A model which may be particularly useful for teaching superordinate concepts with simulation is Taba's instructional model. Taba (1969) identifies

three cognitive tasks involved in the thinking process. The first, concept formation, involves organizing information into a system of classes or groups. In this phase it is sufficient that the facts be introduced and that the learner become somewhat familiar with them. The second cognitive task is interpretation of the data. To do this the learner must relate various kinds of information given and determine cause and effect relationships. Time must be taken to develop concepts, to develop strategies for coordinating lower level concepts and facts, and to make decisions among various alternatives based on the information available. The third cognitive task is problem solving. The learner must be able to apply what he knows, facts and generalizations, to the solution of a problem. This final phase requires additional coordination of facts and concepts, and the development of new strategies for evaluating them.

The purpose of the present study is to examine the effectiveness of simulation as a means of teaching superordinate concepts necessary for the acquisition of subordinate skills. If Case (1975) is correct, then students should demonstrate a knowledge of subordinate concepts when tested at the completion of training on superordinate skills. The encounter with subskills on the test should also constitute a kind of learning trial for the learner. Thus, when tested a second time, student performance should be better. Improved performance would not be expected from students who learned the subskills without benefit of learning the superordinate concepts initially. Previous research on retention indicates that such students are in fact likely to forget some of what they have learned.

Method

Subjects

Fifth- and sixth-grade classes from two Kansas City, Kansas elementary schools were utilized for this investigation. The eight classes participating in this experiment were randomly assigned to experimental and control groups. The total number of students in the sample was 183, including 91 in the experimental group and 92 in the control group.

Treatment

The investigator met with the experimental and control teachers one week prior to beginning the treatment. At this time both groups received the same instructions on the purpose of the study and testing procedures. Experimental and control group meetings were conducted separately.

Teachers in the control group were instructed to teach a map skills lesson which included both facts and concepts in the way they usually teach. Their instructional approaches involved teaching the facts and concepts directly rather than teaching superordinate concepts. The lesson used for the sixth grade was from the textbook *Exploring Regions of the Eastern Hemisphere* and for the fifth grade the lesson was from *Exploring Regions of the Western Hemisphere*, both published by Follett. The lesson was to be taught in four consecutive sixty-minute time periods. Time was allowed after the presentation for discussion and questions.

In the preparation meeting with the experimental group teachers, the game *Phantom Submarine* was played since it has been found that teachers

do a better job of teaching a simulation if they have first played it themselves. At this time the teachers became familiar with the game, discovering the rationale, techniques, and procedures.

The systematic approach of Bruner's and Taba's theories for learning and the approach used with the simulation game *Phantom Submarine* are very similar. It provides opportunities for the teacher to expand pupil participation through the use of peer interaction, role-playing, and decision-making. The primary emphasis is on the need for active rather than passive participation in order to have a meaningful learning experience. The active participation leads to intrinsic motivation that Bruner and Taba mentioned as an important factor in helping children develop greater interest in a subject, which, in turn, leads to longer episodes for learning.

After a lengthy discussion about the game, the timetables were established as follows: (a) On the first day the students in the simulation treatment used the sixty-minute period allowed to familiarize themselves with the game and divide into 5-person groups. Each member of the group had a data card telling some physical characteristic of the floor of the Atlantic Ocean. The simulation began by the group compiling factual knowledge about the floor of the ocean and its currents. This was accomplished by a member of the group showing and reading his card to the rest of the group. As each member read his card, the other members recorded this data on their outline maps. (b) The second day, students were presented a problem which required them to make a decision about where some good places might be to try to bring the submarine up from the bottom of the ocean. They were instructed to use the information included on the maps and consider such factors as water depth, mountain ridges, etc. In considering alternative solutions, certain cause and effect relationships for physical features were discussed. Solutions were discarded or approved on the basis of the relationship among these factors. (c) On the third day, students were presented a final problem: What should be done with the submarine? Students were given roles to play in the context of a meeting at the United Nations. The roles involved a consideration of various economic, political, and ecological concerns. Several general questions were posed to the students in the form: What would happen if? To deal with the questions, students had to apply knowledge of the maps and the generalizations they had formed from the previous two tasks. (d) The fourth day was allowed for completing any unfinished tasks and for discussion of all decisions made by the groups.

Instruments

On the fifth day of the experiment, both the experimental and control groups were administered the posttest, the map portion of the Iowa Test of Basic Skills to measure map skills. Two weeks after the posttest a delayed posttest was given to both groups to measure retention.

Results

Means and standard deviations for the Iowa Test of Basic Skills are presented in Table 1. One-way analyses of variance were used to examine differences in the mean performances of experimental and control groups on the Iowa test. No significant difference between groups was observed on the

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR IOWA TEST OF BASIC SKILLS

	Posttest	Delayed Posttest
Treatment (<i>n</i> = 91)		
Mean	16.82	17.58
SD	4.73	5.23
Control (<i>n</i> = 92)		
Mean	16.19	15.59
SD	5.42	6.23

TABLE 2
SUMMARY TABLE OF ANALYSIS OF VARIANCE FOR
IOWA TESTS OF BASIC SKILLS POSTTEST

Source of Variation	Sum of Squares	df	Mean Square	F
Between	18.0726	1	18.0726	.8279
Within	3950.9384	181	21.8284	
Total	3969.	182		

TABLE 3
SUMMARY TABLE OF ANALYSIS OF VARIANCE FOR
IOWA TESTS OF BASIC SKILLS OF DELAYED POSTTEST

Source of Variation	Sum of Squares	df	Mean Square	F
Between	182.17	1	182.17	5.512*
Within	5982.43	181	33.05	
Total	6164.60	182		

* significant at the .05 level.

posttest (See Table 2). However, a significant difference was observed between experimental and control groups on the delayed posttest (See Table 3). Furthermore, the experimental group tended to improve from the posttest to the delayed posttest while the control group tended to decline — albeit neither trend was statistically significant.

Discussion

Results from the study indicate that the simulation game was an effective way of presenting superordinate concepts so as to facilitate learning of lower level map skills. Performance on the posttest and delayed posttest indicated that learners in the simulation group not only learned as much as learners utilizing more traditional information-processing approaches, but they continued to improve after completion of the training. This subsequent

improvement resulted in superior attainment on the delayed posttest. The findings in this study, which showed that learning superordinate concepts facilitates the learning of subordinate facts and skills, are similar to findings reported by Case (1975) when he trained children to do maze tasks. After training on superordinate concepts, these children tended to improve upon additional encounters with the maze tasks. Children whose training involved only being rewarded for correct approximations to solving the maze task showed no significant advance once the training was terminated. Thus, the present findings tend to corroborate Case's analysis of effective instructional strategies and expand his findings to the learning of several related subordinate concepts.

Educators have not typically espoused the use of simulation games as a means of teaching facts and basic concepts. It seems, however that simulations which involve some aspects of information-processing strategies can be effective in facilitating these types of learning. These types of simulations may serve as useful advance organizers. While utilizing symbols, they are not dependent on written materials. Like other types of experiential learning they involve actions, actions which appear helpful for applying concepts to particulars. Subordinate concepts will not only become "meaningful" in relation to the subordinate concepts presented, but also in relation to the affective response emitted during the actions. As part of a total instructional strategy, simulations offer teachers a useful addition to a repertoire of instructional designs. They provide a change of pace and have been shown to improve attitude toward learning (DeKock, 1969; Cohen, 1969).

Research needs to be aimed at the long-term effects of simulations in facilitating subordinate facts and concepts. In addition, research is needed to examine how simulations might be more effectively integrated into a total instructional approach for a curricular area. Such questions as what types of simulations are needed, how long should they last, how frequently should they be employed and what other types of instructional procedures do they best integrate will need to be considered. Additional research also needs to be done on simulations as advance organizers.

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Comparative Views on School Discipline

An Alberta survey of the views of nine different groups on school discipline was conducted during the 1975-1976 school year. Sponsored by the teachers' and trustees' organizations and the Planning and Research branch of the Department of Education, participation reached an overall rate of 77.6% of potential.

In line with the results of other similar surveys, considerable satisfaction with the existing state of school discipline was found. However, if there were to be any change, participants generally called for stricter discipline. A difference of interpretation of similar results than that usually associated with those of the Gallup poll is presented, along with findings on traditional versus humanistic views about control of student behaviour, findings about the generation gap between parents and offspring, and dimensions of attitudes toward school discipline. (Dr. Clarke is Professor Emeritus at the University of Alberta, and Dr. Hunka is Coordinator of the Education Research Division in the Faculty of Education at the University of Alberta.)

Dictionary definitions of discipline include four major elements: education, training or instruction; authority, obedience, subordination, control, direction, or submission; punishment, chastisement or correction; and a resulting state of order or control. School discipline is a narrower concept which generally includes three elements: goals or standards of behaviour, procedures for attaining these goals or standards, and the resulting state. Thus Dettman in the report of an Australian study, defines discipline as follows:

The discipline of a school is the state or condition of order or good behavior among the students. The term also refers to the procedures by which this state of order is maintained in the school. (1972, p. 7)

As Smith observes, control of behaviour is essential in society, and as far as schools are concerned, this control is generally recognized in statutes and regulations.

The proper functioning of any social system requires some regulation of its members. . . . For a school system to function properly the conduct of pupils must conform to conditions that are conducive to learning. Principals and teachers are by statutes and board regulations charged with the responsibility for maintaining such order in the school. (1969, p. 292)

Usually, there is a provision in law for school boards to make regulations for managing schools, and frequently four areas of control of student behaviour are specifically mentioned in legislation: expulsion, suspension, corporal punishment, and conduct on school buses. The concept of *in loco parentis*, which means that when a parent sends a child to school the parent is presumed to have delegated to school officials the right to make and enforce reasonable rules and regulations, is one basis for school discipline. Barger (1961) deals with the legal status of students in general, and with corporal punishment in some detail. The conclusions from the extensive literature on this aspect of school discipline are presented in a book by Chamberlin (1971), and in articles by Church (1963), and Clarke and MacKenzie (1970).

There have been many recent surveys of school discipline. Bevan (1973), Chalmers (1972), Hodgkinson (1974) each did studies in a particular Canadian city; Fritz (1973) and MacMillan (1973) in a province; and Lauwerys (1973) in a Canada-wide survey included items related to school discipline. Major findings from these Canadian surveys are presented below. The Australian study by Dettman (1972) previously cited is complete and scholarly. The annual Gallup Poll in the United States as reported in Kappan also includes references to school discipline. Some results from the 1976 poll will later be compared with those from an Alberta study (Clarke, 1977).

A number of studies have applied both scientific knowledge and conventional wisdom to classroom management. Considerable research has centered on the application of behaviour modification as exemplified by Bandura (1969), Becker, Engleman, and Thomas (1971), Glavin (1974), Keller and Inesta (1974), MacMillan (1973), and Sulzer and Mayer (1972). Meacham and Wersen (1974) undertook to integrate behaviourism and humanism. Humanism as applied to education is much broader than classroom management, with Combs (1972), and Zahorik and Brubaker (1972) typical exponents. Kounin (1970) is unique in that his proposals about classroom management are based on research. Chamberlin (1971) has produced a well-received book, as have Jessup and Kiley (1971), the latter applying to the high school level.

A Canada-wide study of the purposes of education was conducted by Lauwerys (1973) for the Canadian Education Association. During the 1972-73 school year 1,680 questionnaires were distributed by this Association across Canada. Lauwerys (1973) reports that of 1531 useable returns there were 236 from students, 257 from educators, 699 from parents with children in school, and 339 members of the general public without children in school. This study found that 21.0% of Canadians checked "lack of discipline" as "the biggest problem with which your schools have to deal." Interestingly, 29.7% of the Alberta respondents checked this. As has been found in other studies, concern about discipline was most pronounced in the general public without children in school, followed by that of parents with children in school, followed by that of educators, and exhibited least by students. Another question asked whether the atmosphere of the school was too restrictive (11.9% checked this response),

too permissive (26.6% checked this), or satisfactory (60.2% checked this). Alberta results showed a smaller proportion checking "satisfactory" (49.7%) and a larger proportion checking "too permissive" (41.3%)

A scholarly survey by Hodgkinson (1974) of the junior secondary schools of Greater Victoria used questionnaires and interviews to gather data. His study found that 90% of administrators, 72% of parents, 64% of teachers, but only 36% of students perceived school discipline as major problem. He pointed out that the widest gap existed between parents and their offspring, and that there was no overall support for a permissive approach. The Lethbridge Public School Board, in a report by Bevan (1973) indicated similar findings. A proposal to eliminate almost all rules and have schools operate on mutual trust and understanding was supported by students but not, in general, by educators, parents, or members of the general public. The report concluded that "there was a continuing desire for organization and structure within the schools." Chalmers (1972) completed a survey entitled *1,000,000 Opinions* for the Greater Montreal Protestant School Board. Students, teachers, and parents rated control measures too strict, about right, or too relaxed. Students rated control measures on seven issues (eg., dress, homework, etc.) as too strict, teachers rated them about right on six of the seven issues, and parents, more than did the other groups, rated control as too relaxed.

From these and other studies, it was clear that in the early 1970's school discipline was a matter of concern. Parents and the general public did not favour any relaxation of control of student behaviour. Teachers, and parents of children in school were, to a considerable extent, satisfied with school discipline as it was, but if there were to be any change, it should be that control should be stricter. However, perhaps the most important finding from all studies was the diversity of views on school discipline. While different publics had, in general, different perceptions about school discipline, the range of views in any one public was great. Majority support for any end state or specific procedure of school discipline was rare.

Research Design, Alberta School Discipline Study

In the 1975-76 school year, a study of school discipline was sponsored by The Alberta Teachers' Association, The Alberta School Trustees' Association, and Alberta Education, and was funded by the latter. It was also supported by The Alberta Federation of Home and Schools and the Conference of Alberta School Superintendents.

A sample of 100 schools, stratified by size, grade level, and geographic location to be representative of the 1,277 schools in the province was selected, and in fact 100 schools with the required characteristics did participate. Associated administrative units and regional offices were also included. Data were collected by means of a one-sheet (two-page) questionnaire which was identical for each of the participating groups. There were two open-ended questions on the state of school discipline: what *is* discipline like in your school(s)?, and what *should* discipline be like in your school(s)? Connected with the first was a rated type item, on a seven-point scale: 1—altogether too strict, 2—too strict, 3—just about right, perhaps a bit too strict, 4—just about right, 5—just about right, perhaps a bit too lenient, 6—too lenient, 7—altogether too lenient. The rated type item connected with the second was: 1—

much more strict, 2—more strict, 3—perhaps a bit more strict, 4—about as it is now, 5—perhaps a bit more lenient, 6—more lenient, 7—much more lenient. There was another open-ended item asking participants to list one or two causes of school discipline problems. Finally, there were nine suggestions for improving school discipline to be rated on a seven-point scale from 1 (excellent) to 7 (no good, forget it). In total, there were eleven items to be rated, the last nine being as follows:

3. Make schoolwork more interesting and more what kids want to study.
4. After elementary school, let any student of any age who wants to quit school do so.
5. Make sure that students do their schoolwork properly and on time.
6. Give special help to students who cause discipline problems, if necessary putting them in special classes or even schools.
7. Give students more freedom, accept what they do, encourage them to develop self-discipline, and accept some misbehaviour as being part of growing up.
8. Encourage parents to back up the school on what it is doing to get school discipline.
9. Give special help to teachers who are having discipline problems such as special conferences, group sessions, assistance as required.
10. Do whatever is necessary or use whatever measures are necessary (including using the strap) as much as is necessary to keep discipline.
11. Let students help to make and run school rules (guides to conduct).

Participant anonymity was insured by using confidentially marked envelopes. The responses to the open-ended questions were classified by four persons following a carefully prepared key. The ratings of the three largest groups (teachers, parents, students) were factor analyzed to ascertain whether common factors were involved.

Results

The response to the questionnaires was excellent. There were useable returns from 5,228 participants: 100 principals, 80 vice-principals, 1,309 teachers, 1,406 students, 1,715 parents, 48 superintendents, 233 central office personnel, 273 trustees and 64 regional office personnel. Participation ranged from 72% to 100% in the various groups, with an overall rate of 77.6%.

The major findings are summarized below and in greater detail in the *General Report of the Alberta School Discipline Study* (Clarke, 1977). As Table 1 reveals, the responses of the participants were divergent. They spread across the spectrum of possible views on most matters of school discipline. Every group, and all participants together, exhibited this divergence of view. The reaction of the largest single number of participants, a plurality of 41 percent of all participants, was that school discipline as it was in the 1975-76 school year was just about right. Parents especially (47 percent) endorsed this view. Second to satisfaction with school discipline as it was, the next largest number of participants (32 percent) expressed the view that school discipline was too lenient. Consistently, in responding to what school discipline should be like, 34 percent called for it to be stricter.

A number of suggestions for improving school discipline were rated by the participants. The one which exhibited least divergence and most unanimity of view was opposition to the suggestion that after elementary school, any

TABLE 1
RATING OF PRESENT STATE OF SCHOOL DISCIPLINE

Participants	Rating							Totals
	too strict		about right			too lenient		
	1	2	3	4	5	6	7	
Teachers	3 0.3%	7 0.6%	38 3.2%	444 37.2%	461 38.6%	201 16.8%	39 3.3%	1193
Students	33 2.5%	68 5.0%	327 24.3%	551 41.0%	276 20.5%	71 5.3%	18 1.3%	1344
Parents	3 0.2%	19 1.2%	86 5.5%	728 46.8%	470 30.2%	203 13.0%	47 3.0%	1556
Principals	0 0.0%	1 1.0%	3 3.1%	54 55.7%	37 38.1%	2 2.1%	0 0.0%	97
Vice-Principals	0 0.0%	1 1.3%	2 2.6%	36 47.4%	30 39.5%	4 5.3%	1 1.3%	76
Superintendents	0 0.0%	2 4.3%	6 12.8%	16 34.0%	22 46.8%	1 2.1%	0 0.0%	47
Central Office	0 0.0%	1 0.5%	18 8.2%	70 31.8%	94 42.7%	33 15.0%	4 1.8%	220
Trustees	0 0.0%	0 0.0%	5 1.9%	63 24.2%	125 48.1%	63 24.2%	4 1.5%	260
Regional Office	0 0.0%	4 7.5%	2 3.8%	17 32.0%	21 39.6%	9 17.0%	0 0.0%	53
All Participants	39 0.8%	103 2.1%	487 10.1%	1979 40.9%	1536 31.7%	587 12.1%	113 2.3%	4844

student of any age who wanted to quit school should be permitted to do so. Suggestions that students who were discipline problems, and teachers who were having discipline problems, should be provided with help were rated good to very good. An inducement, “making schoolwork more interesting and more what kids wanted to study” was considered a good idea by students but received lukewarm support from other groups. Another, that students participate in making and enforcing school rules, received little support even from students, and at the elementary school level was deemed inappropriate, especially by parents and teachers.

Following the suggestions for improving school discipline which were to be rated, there was a space for a write-in suggestion. Over 1,000 participants availed themselves of this opportunity, with the most frequent suggestion calling for participation (146 write-ins) followed by standards (123), school conditions such as good extracurricular programs (89), and understanding and accepting students (67). A classification of open-ended responses indicated that the cause of discipline problems most frequently mentioned was students who would not behave properly: they lacked respect for authority and property, exhibited poor attitudes, lacked self-discipline, etc. The second most frequently mentioned cause was lack of discipline in the home. The location of 70 percent of the 9,110 causes listed by the participants was in the school. Another 21 percent of the causes of school discipline problems were located outside the school: in the home, society, etc. The remainder were located in the relationship between the home and the school.

The views of teachers on school discipline were, on the whole, remarkably uniform. Female teachers were more opposed to letting students quit school, and were more in favour of encouraging parents to back up the school, and helping teachers who were having discipline problems than were male teachers. Beyond these differences, there were no other clearcut results. Teachers over 30, as might be expected, held more traditional, conservative, or tough-minded views on school discipline than did teachers 30 years of age and younger. Similarly, mathematics and science teachers held more traditional, conservative, or tough-minded views than did English and social studies teachers. The same kinds of differences were exhibited between classroom and non-classroom teachers, and between classroom teachers and guidance counsellors.

Students who aspired to matriculation, college or university were much more traditional, conservative, or tough-minded in their views on school discipline than were the non-matriculation and non-college bound students. Paradoxically, the first group was also more in favour of humanistic measures of student behaviour control. These findings support the conventional wisdom that it is the nonacademic student who turns to misbehaviour.

There was a marked difference in views on school discipline in parents over 30 years of age in contrast with those 30 years of age or younger. The former were more traditional, conservative, or tough-minded. A similar difference was exhibited between parents of "two-parent" and "one-parent" families.

There were a number of expected group differences in views on school discipline. The views of teachers and trustees were close together on what discipline *was* like and on what it *should be* like. At the opposite pole were students and superintendents. For further illustrations of group differences, the reader is referred to Clarke (1977). Although groups differed one from another in their views on school discipline, group differences were overshadowed by the diversity of view within any one group.

An important finding of the study was that for elementary schools, in the view of participants with respect to school discipline, big was bad and small was good. That is, teachers, parents, and other participants associated with large schools rated discipline as being worse than did the corresponding groups associated with small schools.

The following sections provide somewhat more detail on four other findings: comparisons with Gallup Poll results, traditional vs. humanistic attitudes to student control, the generation gap, and dimensions of attitudes toward school discipline.

Comparisons With Gallup Poll Results

The eighth annual Gallup Poll of the American public's attitudes toward the public schools as reported in the October, 1976 issue of Kappan continues to reinforce the impression that discipline is the number one problem. The report uses these words:

Discipline continues to head the list of major problems when a sample of the nation's adults cite what they perceive as the most important problems of the public schools in their own communities. In fact, discipline has been named most often seven times during the last eight years.

TABLE 2
COMPARISON OF GALLUP POLL AND ALBERTA FINDINGS

Attitude toward discipline	Response
Discipline is poor (Alberta)	27%
Lack of discipline (Gallup)	22%
Discipline is good (Alberta)	55.9%
Discipline is good (Gallup)	--

Newspaper headlines, which catch the phrase, "Discipline, the schools' number one problem" have probably implanted the idea in the minds of many.

As Table 2 reveals, some findings of the Alberta study were similar to those of the American study, but the latter did not provide an opportunity for participants to rate the present state of school discipline. The comparisons should not be pushed too far because the questions asked were not identical, the samples differed, and the classification of open-ended responses is always a matter of interpretation in borderline cases. However, as can be seen from Table 2 as well as from an examination of the results of the rating type items as presented in Table 1, the Alberta respondents exhibited considerable satisfaction with school discipline. This is a far cry from the impression created by the headlines, "Discipline, the school's number one problem."

Traditional vs. Humanistic Attitudes to Student Control

Carlson (1964) proposed a theoretical framework which was developed by Willower (1967) and his associates at Penn State. They developed a Pupil Control Ideology instrument which was used by Fritz (1973) in Alberta and MacMillan (1973) in Nova Scotia. This instrument was not used in the Alberta School Discipline study but two items, to be rated on a seven-point scale as suggestions for improving school discipline, were designed to tap the theoretical positions mentioned.

The item designed to tap the traditional position (called custodial by the originators) was as follows: "Do whatever is necessary or use whatever measures are necessary (including using the strap) as much as is necessary to keep discipline." Responses to this item showed that participants were markedly divided. Thus 13.6% rated it 1 (excellent, tops) and at the other extreme, 14.5% rated it 7 (no good, forget it). There was 13.8% who rated it 2 (very good), 14.5% who rated it 6 (little good), and 16.0% who rated it 3 (good) while 9.5% rated it 5 (might be some good). Only 18.1% selected the neutral or middle position. Teachers and trustees favoured this suggestion, while regional office personnel and central office personnel opposed it (followed by students!).

The item designed to tap the humanistic position was as follows: "Give students more freedom, accept what they do, encourage them to develop self-discipline, and accept that some misbehaviour is part of growing up". The response of participants showed divided views with the majority opposed.

The ratings were (see above for descriptions): 1, 7.9%; 2, 10.8%; 3, 16.1%; 4, 19.3%; 5, 11.9%; 6, 17.0%; 7, 17.1%. Students and regional office personnel favoured this suggestion while parents and trustees opposed it.

It is clear from the above results that no consensus was present about traditional measures for student control. In general, the traditional mode of student behaviour control received majority support, but sizeable proportions of participants held strong views both for and against. The humanistic position on student behaviour control measures as expressed in the item used was not supported by a majority. Again there was divided opinion, with sizeable proportions strongly opposed and somewhat smaller proportions strongly in favour.

The Generation Gap

Of the 1,406 students and 1,715 parents who participated in the study, 1,338 were matched, parent with offspring. The correlations between student and parent ratings on the eleven rating scale type items are shown in Table 3. These correlations are all low, but they are all positive. The greatest tendency for a high parental rating of an item to be associated with a high student offspring rating of the same item (or low with low) was demonstrated in item 10, traditional measures for control of student behaviour, where $r = 0.310$. The least such tendency was exhibited in item 6, provide special help for students who cause discipline problems, where $r = 0.139$.

This may be a surprising result for those who think in terms of a generation gap, because it supports the old saying, "like parent, like child." This tendency is present for all eleven items.

Table 3 also demonstrates the generation gap. It shows the mean position of the 1,388 parents compared with the mean position of their 1,388 offspring on the various items. All except one of the differences shown was significant at the 0.05 level of confidence. With respect to item 1, parents rated school

TABLE 3
COMPARISONS OF PARENT-OFFSPRING MEAN POSITIONS
ON SCHOOL DISCIPLINE

Number and Paraphrase of Items	Mean Parents	Mean Students	Correlation
<u>Is and Should Be</u>			
1. What discipline is like	4.24	3.84	0.255
2. What should discipline be like	3.01	3.86	0.209
<u>Suggestions to Improve/Discipline</u>			
10. Traditional measures for discipline	3.43	4.43	0.310
4. Let students quit after elementary school	6.07*	6.05 *	0.279
3. Make schoolwork more interesting	3.20	2.66	0.275
7. Humanistic measures for discipline	4.49	3.54	0.223
8. Encourage parents to back up school	1.98	3.44	0.216
11. Let students help run school	3.79	3.57	0.215
9. Special help to teachers	2.37	3.16	0.163
5. Schoolwork done properly and on time	2.10	3.21	0.161
6. Special help to students	2.84	3.56	0.139

* difference not significant at .05 level of confidence.

discipline as more lenient than did their offspring, and consistently, in item 2 indicated by their rating it should be stricter to a greater extent than did their offspring. In the suggestions for improving school discipline, parents rated item 10, traditional measures for control of student behaviour, much more favourably than did students. The balance of the items under this heading are interpreted in the same way: lower numbers mean a more favourable rating. All of the differences are in the expected directions, and all are statistically significant at the 0.05 level of confidence except one.

These results were seemingly a paradox. There was a positive correlation between parents' views and those of their offspring. Like parent, like child. Yet there was a pronounced generation gap, in the expected directions on the various items. In general, parents favoured stricter control and requiring students to perform. The findings of the study support both positions.

Dimensions of Attitudes Toward School Discipline

The eleven items which participants rated were factor analyzed for three groups: teachers (1,309), students (1,406), and parents (1,715). A principal factor analysis with squared multiple correlations used as communality was performed separately for each group. The results are shown in Table 4.

Factor I, TRADITIONALISM IN TRANSITION, includes these items:

5. Make sure that students do their homework properly and on time.
8. Encourage parents to back up the school on what it is doing to get school discipline.
10. Do whatever is necessary or use whatever measures are necessary (including using the strap) as much as is necessary to keep discipline.
6. Give special help to students who cause disciplinary problems, if necessary putting them in special classes or even schools.

TABLE 4
VARIMAX FACTOR LOADING MATRIX

Item	Teachers		Parents		Students	
Factor	I	II	I	II	I	II
5	0.48	-0.11	0.52	0.05	0.56	-0.01
8	0.50	0.02	0.62	0.08	0.55	0.11
10	0.46	-0.22	0.58	-0.03	0.61	-0.09
6	0.41	0.09	0.46	0.27	0.49	0.14
9	0.40	0.25	0.46	0.29	0.45	0.26
3	0.14	0.51	0.10	0.53	0.06	0.44
11	0.20	0.45	0.19	0.53	0.09	0.52
7	0.07	0.59	0.09	0.66	-0.01	0.57
4	0.14	0.02	0.33	0.48	0.22	0.41
1	-0.16	0.41	-0.07	0.38	-0.28	0.42
2	0.19	-0.35	0.26	0.04	0.43	-0.33
Percent of Total Variance	11.6%	10.2%	20.6%	8.3%	16.0%	12.1%

9. Give special help to teachers who are having discipline problems such as special conferences, group sessions, assistance as required.

A common thread running through these items is an emphasis on standards, upholding standards, and on excellence. It reflects the position that the school is responsible for ensuring student learning; traditionalism tempered with compassion. The factor was identified as one of "traditionalism in transition."

Factor II, HUMANISM, includes these items:

3. Make schoolwork more interesting and more what kids want to study.
11. Let students help to make and run school rules (guides to conduct).
7. Give students more freedom, accept what they do, encourage them to develop self-discipline, and accept that some misbehaviour is a part of growing up.
4. After elementary school, let any student of any age who wants to quit school do so.
1. What do you think about discipline in your school?

A common thread running through these items is freedom for self expression, freedom to grow. It is laissez-faire with social compassion; the school is responsible for permitting students to develop. It includes the idea of helping the student to unfold. It calls for freedom to grow. The factor was identified as "humanism." The two factors which appeared account for one-quarter to one-third of the variance exhibited. It is important to note that the factors apply to each of the groups: teachers, parents, and students. The one exception is that item 4 above, for teachers, does not belong in Factor II, Humanism. It may be that teachers who were in favour of students quitting school were, in fact, traditional in their attitudes.

Item 2 was, "What should discipline be like in your school?" This question, for both students and teachers is related to both traditionalism in transition and to humanism. However, for parents, this item appears not to be in those domains. That students' attitudes toward school discipline are in the same domain as are teachers' and parents' is a matter of note. It may be that students can accept the traditionalism in transition position so long as it is fair. Traditionalism has often been equated with custodialism, and traditional attitudes about student control in school linked, as was the traditional-humanistic control orientation, to the attitudes associated with control in prisons and mental hospitals. While this may have held in the past, the present study finds a less restrictive and more compassionate component. Scholarship, excellence, and standards remain, but they are tempered with social compassion.

Humanism may be an emerging or evolving attitude toward student control. In the words of youth, it is "do your own thing," or in the words of Abraham Maslow, "what a man *can* be, he *must* be" (self-actualization). Even students accept the traditional position (excellence) and accept that behaviour must be controlled, either internally or externally. Their one caveat seems to be that control is fair.

Conclusions

The findings of the the present study indicate that there was considerable satisfaction with the state of school discipline at the time the study was made.

However, there was support for stricter disciplinary procedures and, consistently, little support for less restrictive control measures.

In general, it has been found that the public at large is most critical of school discipline, followed by parents and school personnel. In the Alberta study, teachers and trustees were more strongly in favour of stricter discipline than were parents of students. While there is no doubt that grade level and community expectations affect views on school discipline, the general findings support the view that an overriding factor is the expectations people hold. The temper of the times, or the social context, appears to be the most influential factor determining views on school discipline.

The diversity of view exhibited by participants from any one group was great. This, rather than consensus, was the rule. School disciplines is not a single unitary matter toward which group consensus of viewpoint is exhibited. Rather, there is such diversity of view even within any one group such as teachers, parents, or students that a change in emphasis or procedures would inevitably please some and displease others.

The complexity of school discipline is such that the approach used in any study can predetermine results unless care is taken to provide open-ended responses or sufficient alternatives to cover most of the views participants hold. In terms of the media, contradictory headlines could well be used to highlight the same data.

The strengths of the present study were its province-wide extent, the use of one instrument for all participants, the open-ended items, the carefully chosen representative sample, and the preparation and backing which helped produce the high rate of return of questionnaires. The weaknesses were that it was place-bound and time-bound to Alberta in the mid 1970s, it relied on a questionnaire, open-ended items had to be classified, discipline was not defined for the participants, the groups studied were limited to nine, and the context in which discipline was set (social trends) were not studied.

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BOOK REVIEWS

APPLYING BEHAVIOUR-ANALYSIS PROCEDURES WITH CHILDREN AND YOUTH. *By B. Sulzer-Azaroff and G. R. Mayer.* Toronto: Holt, Rinehart and Winston, 1977.

Nathan Azrin, in the Foreword to the book, describes the extensive and varied experiences the authors have had that make them "uniquely qualified" to write the book. Their experience reportedly has included public schools from the primary grades through high school, special education classes, residential institutions and parent-child interactions. They have worked with children in regular classrooms as well as with emotionally disturbed, profoundly to mildly retarded, and autistic children.

This wealth of experience is certainly expressed in the variety of examples used in this topically comprehensive, practical and informative book on applied behaviour analysis.

The thirty five units of the text provide a complete, sequential model of applied behaviour-analysis (ABA). The following topics are reviewed:

- a) contemporary legal/ethical issues
- b) selection of goals and objectives
- c) reliability, validity and utility of various data recording methods
- d) the advantages, disadvantages, selection, implementation and evaluation of a variety of intervention strategies to increase, decrease, teach, extend and maintain behaviour
- e) applied behaviour analysis (ABA) research design procedures, and
- f) method for communicating results of ABA programs.

The book is five hundred and two pages in length, plus a brief appendix of behavioural assessment systems, an excellent fifteen-page glossary of technical terms, and a comprehensive, detailed, and well organized subject index.

Performance goals are stated at the beginning of each unit and additional advance organizers are frequently incorporated into the body of the text. These features help to orient the reader, focus his attention on essential issues, and guide his progress through the material. Each unit concludes with a brief summary. Technical terms, defined in the context and in the glossary, are printed in bold type.

An outstanding feature of the book is the use of check lists, tables and flow charts that summarize the material and sequentially list the major points to

facilitate decision-making during selection and application of behavioural techniques. For example, decision-making flow charts are provided for:

- a) practical considerations to make before implementing an ABA program
- b) selecting priorities in establishing goals, and
- c) selecting and implementing recording techniques, procedural strategies and functional analysis designs.

With these features the text will function as a continuing reference for practising applied behaviour-analysts.

A study guide describes field activities designed to provide students with the opportunity to observe, design, implement and evaluate programs. Sets of quizzes and marking keys are available from the publisher upon request.

Throughout the text, the authors emphasize the use of positive, constructive, adaptive, and minimally intrusive methods of behaviour management rather than coercive, suppressive, or merely institutionally expedient procedures. The authors also stress concern for the protection of human rights. They discuss the concepts of voluntary, informed consent and client involvement in treatment selection and evaluation. Emphasis is also placed upon accountability, and ethical and legal responsibility. Several recent U.S. court cases are discussed as are practical methods for avoiding the violation of human rights, litigation, and overly restricted legislation. Although the discussion relates specifically to the United States, the problems described are universal. An awareness of the U.S. experience may give Canadian readers the advantage of repeating some of the successes achieved while avoiding some of the problems.

In the preface to the book the authors describe several ways in which the text may be used:

- a) in conjunction with the study guide and practicums to train professional competencies over one academic year;
- b) to train technical and paraprofessional competencies in a one-semester course;
- c) to train parents, teacher, ward staff and others in a two-semester program; and
- d) to provide inservice training on special topics.

Selected portions of the text are designated for the various programs. The impression that the book provides an answer to most training needs in the use of applied behaviour analysis procedures may be heightened by the use of examples drawn from schools, hospitals, residential facilities, institutions, and clinics working with medical, psychiatric, social, educational and family problems.

The variety of examples cited in the text certainly emphasize the generality of the ABA techniques. However, the variety of examples used may actually impede learning. Optimal generalization of techniques and transfer of principles into practice is achieved when instruction includes examples describing conditions common to the environment in which the learner is expected to perform. The drawing of examples from many different areas of application reduces the number of examples taken from any one area. Student teachers, for example, may have difficulty seeing the educational relevance of "stimulus control" when the examples provided describe a pilot landing in a dense overcast, and a doctor making a diagnosis based on the presence of particular symptoms.

In the foreword to the text, Azrin suggests that the last section of the book on research methods and reporting skills is ideally suited to graduate students and provides an excellent foundation for designing behavioural experiments for theses. In my opinion, the text is suitable as an introduction to applied behaviour-analysis possibly for senior level undergraduates and preferably for graduate students in clinical counselling, community psychology or educational psychology.

Azrin also suggests that the content provides a self-contained cookbook describing in a step-by-step manner what to do. The impression might be given that one has only to read the text to become a competent applied behaviour-analyst. The authors, however, state throughout the text that supervised practice is a prerequisite to competence. They state that "change agents must be adequately trained . . . and they must be regularly supervised . . . training alone is not enough to guarantee that a procedure will be implemented properly" (p. 85).

A supervised practicum is, for three reasons, a necessary complement to the text. First, as discussed, the variety of examples used in the text do not appear optimally to facilitate transfer and generalization. Second, the vast majority of instructional objectives stated at the beginning of each unit are at the knowledge and comprehension level of Bloom's Taxonomy and are not directed to the application of techniques in the solution of practical problems. Thirdly, inadequately trained practitioners may misapply techniques producing failures for themselves and their clients, resulting in the possible rejection of potentially useful methods. Thus, as the authors suggest, the text should be used in conjunction with a supervised practicum.

The text does not have an inspiring beginning. Chapter one begins with an abstract definition of applied behaviour analysis, a discussion of the principles of behaviour, an introduction to technical terminology, a review of the responsible application of behaviour analysis techniques, and a list of the areas in which the methods have been used successfully. Similarly, units two and three describe procedural and ethical considerations. The examples cited describe the hypothetical problems of Flossie, Lucretia, Mr. Grump, and Dexter. Greater reader interest and understanding may have been achieved through the use of an extended description of actual applications of the techniques in the solution of real problems. There are many exciting examples to choose from in the literature that demonstrate definitional, procedural, ethical, and other basic concepts in an interesting and inspiring manner.

The discussion in units two and seven on narrative recording and sequence analysis describe a procedure whereby the sequences of antecedent events, problem behaviours and their consequences are recorded in "running descriptions" over several days of observation. After four hundred events have been recorded "a trend might become manifest." The sheer size of this task is certain to alienate many readers. In most communities there are few people available with the time and expertise necessary to employ this approach in a valid and reliable manner. In addition, the text does not adequately describe how to select, collect, or analyze the data.

The book provides a topically comprehensive, practical approach to the selection, application, and evaluation of applied behaviour management techniques for a variety of problems and situations. The authors emphasize a legally and ethically responsible, positive approach to behaviour management.

The text is clearly written and many of the major points have been

excellently summarized in check lists, tables and flow charts. These devices facilitate organization of newly learned material and will continue to function as practical references during application of the ABA techniques.

Because the authors have drawn their examples from such a broad variety of contexts, students specializing within a particular area, for example Education, will likely require considerable instructional assistance in putting the examples into an educational perspective. Extensive supervised practicum experience will be required to assist the transfer of theory into practice.

The text is suitable for the introductory training of "applied behaviour-analysts" possibly at the upper undergraduate level and preferably at the graduate level during a one-year course as a part of a clinical counselling, community psychology, or educational psychology program.

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TEACHING LOW-ACHIEVING CHILDREN READING, SPELLING AND HANDWRITING: DEVELOPING PERCEPTUAL SKILLS WITH THE GRAPHIC SYMBOLS OF LANGUAGE. *By Annabelle M. Markoff.* Springfield, Illinois: Charles C. Thomas 1976.

Although there has been an increasing number of texts which suggest integration of language arts for average and high-achieving students, Annabelle Markoff's book is one of the few recent publications which attempts to delineate an integrated program for low-achieving children. In this regard the title of her book is somewhat reminiscent of Gillingham and Stillman's *Remedial Training for Children with Specific Disability in Reading, Spelling and Penmanship* first published in 1940. The major purpose of Markoff's book, however, is markedly different from the Gillingham-Stillman volume, growing out of her concern with the current emphasis on geometric forms in perceptual training as evidenced in the work of Frostig, Kephart and Kirk. She attempts to provide a rationale for shifting the emphasis in perceptual training away from geometric forms to basic language forms involving sounds, letters, and words. This is a very welcome shift and one which has considerable research support. Her second major purpose is to suggest teaching techniques for integrating perceptual training in the teaching of the subjects themselves.

As evidence of Markoff's concern with providing a rationale for curriculum decisions with low-achieving children, she devotes the first chapter to a discussion of the relationships between reading and spelling. Both are seen as communication processes: in reading, one translates symbols into meaning; in spelling, meaning is translated into symbols. She emphasizes the importance of meaning, and it appears in this initial chapter that she is using spelling as a term synonymous with written composition. However the meaning dimension, although receiving considerable attention in the chapter on reading, is considered only minimally in the chapter on spelling and almost not at all in the one on handwriting. Hence, the last half of the book seems only marginally related to the theoretical background presented in the first chapter. In addition, Markoff does not systematically review the literature when building her theoretical framework, but draws

heavily from research in educational psychology, particularly from E. Gibson's *Principles of Perceptual Learning and Development*. She makes little reference to studies or theories produced by reading educators, and makes many definitive statements about how people read and spell with little attempt to provide research support.

In the chapter on reading, Markoff deals with six areas: perceptual skill, decoding, vocabulary, fluency, comprehension, and motivation. She expresses concern with the decoding-comprehension dichotomy prevalent in the literature, and is particularly concerned about the heavy emphasis on decoding (word analysis) frequently found in programs for low-achieving readers. She correctly suggests, "To teach reading as a decoding process or separate it from . . . the communication process itself, is a short-sighted solution" (p. 94). The remainder of the chapter, however, is somewhat disappointing in terms of both cohesiveness and the relationship of teaching suggestions to theory and research in reading. She relies heavily on the work of Montessori and Fernald to suggest a multi-sensory approach to teaching letter and word identification. She then turns to a discussion of the language experience story and suggests its use daily with low-achieving students to "supplement, complement and integrate all forms of language instruction." She presents this "integrative vehicle" as the key to developing comprehension, fluency and motivation. There is very little research to demonstrate the superiority of either a multi-sensory or language experience approach with low-achieving children but this does not deter Markoff from making a very strong statement about the usefulness of these techniques. At this point in time judicious use of language experience stories seems to be supported by conventional wisdom, but to claim, as Markoff does, that this has a scientific basis is questionable.

The chapters on spelling and handwriting are, like the chapter on reading, a mixture of ideas gleaned from research and Markoff's own work in special education. She places heavy emphasis on the perceptual aspects of spelling and handwriting, and gives considerable attention to modalities in her discussion. In her suggestions for teaching spelling, she deals largely with isolated words and, with the exception of meaning vocabulary, treats spelling as distinct from the other language arts. In both this and the chapter on handwriting, her emphasis is on the importance of helping children establish distinctive features of letters and sounds. A multi-sensory approach with a heavy motor component is suggested similar to that in the chapter on reading.

Editorially this book has several weaknesses. The order of the chapters noted on the bookjacket does not correspond to that in the text. There are also numerous references within the text to other sections which results in confusion because of this change in order. At several points Markoff refers to an appendix which is nonexistent, and there are a large number of typographical errors. Finally, the literature reviewed in the book is both narrow and somewhat outdated as the latest reference is 1974.

The basic weakness, however, relates to Markoff's attempt to wed theory and practice in teaching low-achieving children. She states in the preface to this book that it started as a series of teaching suggestions for students in special education and regular classroom situations, and that this book was an attempt to organize these ideas into a theoretical framework. She appears to have made a priori curriculum decisions and then to have searched for a theory to support these decisions, rather than making curriculum decisions on the basis of a sound theoretical formulation. This has resulted in

inconsistency among ideas at several points and, in the last two chapters, the addition of another “teaching idea” after the summary to the chapter. Hence, although she provides several useful suggestions, the overall effect has been somewhat less integrated than intended.

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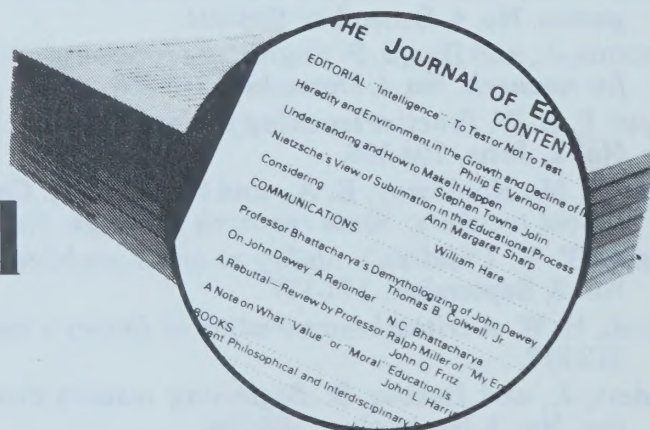
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